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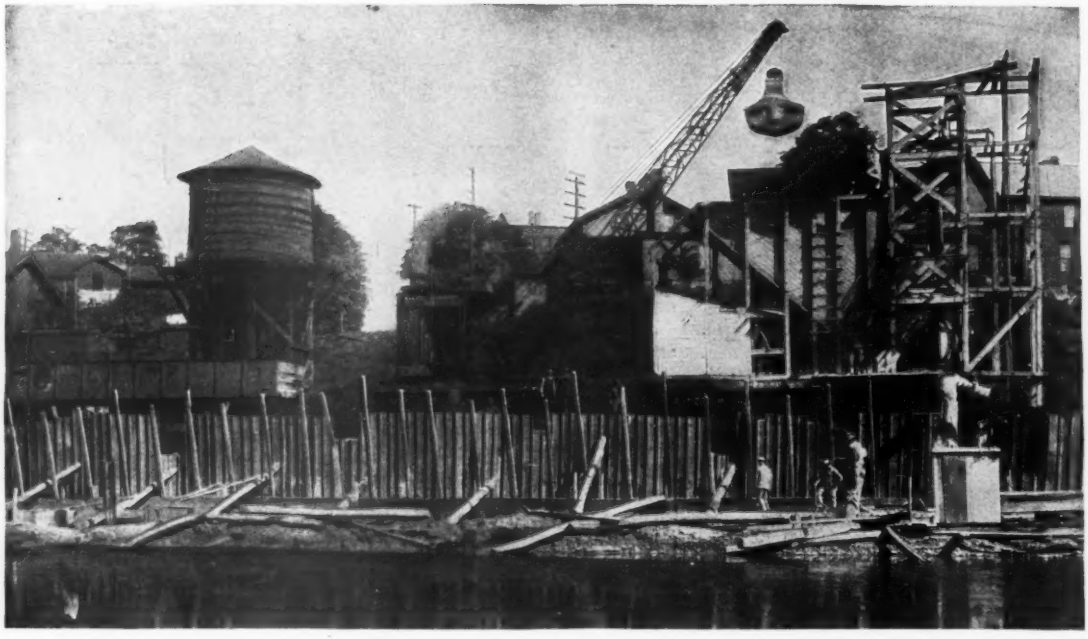

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Engineering News

VOLUME 77 FEBRUARY 8, 1917 NUMBER 6

Old Ohio River Bridge at Louisville—Nearly Fifty Years in Service

Modernization is about to destroy a landmark of bridge engineering, the Louisville bridge across the Ohio River between Louisville, Ky., and Jeffersonville, Ind., used by the Pennsylvania Lines West of Pittsburgh. Its larger part consists of spans of the long-obsolete Fink type. It is one of the few surviving railway bridges having cast-iron members. It has been continuously in railway service for 47 years and now is not worn out, but is forced into the scrap heap by the increase of railway loads and the need for a second track.

FIG. 1. AN EARLY PHOTOGRAPH OF THE OLD LOUISVILLE BRIDGE, COMPLETED IN 1870

One of the unsymmetrical Fink spans, 12 panels, 180 ft. long, is seen in the foreground; the nearer through span is the 400-ft. Indiana Channel span

In 1872, two years after the completion of the Louisville bridge, Albert Fink, in writing the Chief Engineer's final report, said: "The bridge has . . . stood during that time as severe a test as it can ever be subjected to. Experience so far has not developed any defect either in plan or execution."

The bridge has stood since that early day the test of modern railway traffic, far more severe than any foreseen by Fink. Engineers of the present day will readily grant that it has proved itself remarkably durable and that it bears testimony to the excellent work of the bridge engineers of half a century ago.

In its 47 years of service the bridge has required practically no repairs and no reconstruction or replacement except in the floor system. It has had only three coats of paint since its first field painting.

The bridge is practically a mile long (5250 ft.). It consists of a long succession of deck spans of the truss-rod type, originated by Fink, in spans up to 245 ft. 5 in., and two through channel spans of Warren type with vertical hangers and subtie system. Its top chords are of cast iron—octagonal with a round central hole, the ends squared. Its bottom chords and tension diagonals are of eye-bars, and its posts and compression diagonals of Phœnix columns.

Fig. 1 shows the bridge as it was built, and as the larger part of the structure—it is in process of replacement—still appears today. The Portland Canal draw at the Louisville end (see span diagram, Fig. 2) was replaced 15 years ago by a "modern" Pratt truss draw, which except for the difference in type and make-up looks as old now as the rest of the bridge.

The deck spans are typified in all details by the longest, the 245-ft. 5-in. spans of 16 panels, Fig. 3. However, there are 10-panel and 12-panel spans also, and their webbing necessarily is unsymmetrical (see near span in Fig. 1). The sketches in Fig. 4 give the arrangement of posts and truss rods. The 50-ft. approach spans have four panels, the 210-ft. spans 16 panels like the longer ones.

Cast-iron arch floorbeams with iron tie-rods are a special feature of these Fink spans. Their form is

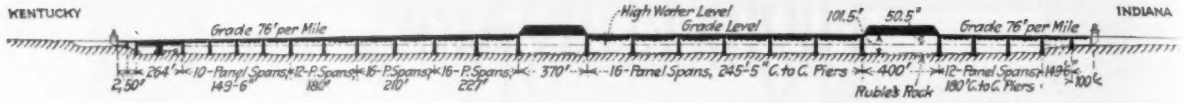


FIG. 2. DIAGRAM ELEVATION OF LOUISVILLE BRIDGE ACROSS THE OHIO RIVER

clearly apparent from the cross-section in Fig. 3. The end of the floorbeam forms the connection block between post and top chord, and the floorbeams themselves constitute also the upper struts of the sway system. Therefore, although the floor loads today are being carried by steel floorbeams (placed 25 years ago), the old cast-iron floorbeams are still in place. The lower struts of the sway bracing are also cast-iron members.

In their 20 years' service the cast-iron floorbeams gave some trouble. Their tie-bars, originally shrunk on, tended to become loose—it was believed because of wear at the pins. Some of them were reshrunk, while others

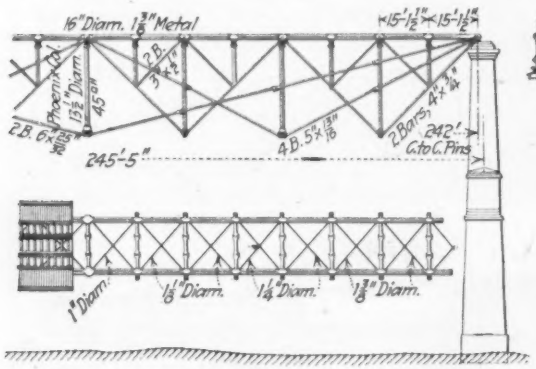
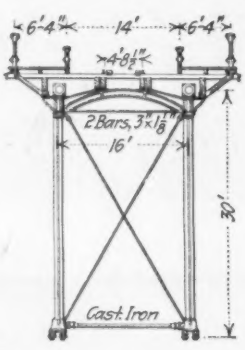


FIG. 3. FINK DECK SPAN OF 16 PANELS, LOUISVILLE BRIDGE



girder yet completed in America" and from the heavy sections required in the individual members. The posts, Phœnix columns, range from 5½ to 17 in. in diameter and have sectional areas from 5.7 to 60 sq.in. Members of double the latter size might have been beyond the manufacturing resources of the day, and in any case the details of their connection to the eye-bars would have been very difficult. Probably the same is true of the cast-iron top chords, octagonal sections of 14 in. in diameter, with central circular hole giving 1- to 1½-in. thickness of iron.

The duplex truss construction (see the cross-section in Fig. 7, which shows the complete independence of the component trusses) presented an interesting difficulty. It was necessary to connect the component trusses together and at the same time make each carry its own

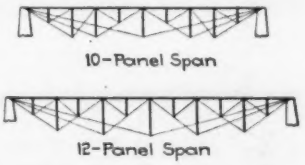


FIG. 4. DIAGRAMS OF FINK TRUSS SPANS

were fitted with turnbuckles. After many years one of the arches broke on account of loose tie-bars; it was not strong enough as a beam to carry the stringer load.

In 1891 the cast-iron floorbeams in all the deck spans were displaced by steel (that is, put out of service, though left in position). A pair of shallow plate-girders was set at each floorbeam, a girder on either side of the arch, with ends resting on the top chords of the trusses.

Wooden Stringers in Service 25 to 35 Years

The original stringers throughout the bridge, on the through spans as well as the deck spans, were pairs of 8x16-in. white-pine timbers. As they rotted out, they were replaced by yellow-pine timbers of the same size. Some time after the floorbeam replacement on the deck spans, however, a start was made in putting in steel I-beam stringers. The stringers of the two through spans and the six deck spans between were replaced by steel in 1895 and 1896. Ten years later the remaining spans were equipped similarly.

In general, the durability of the timber was very satisfactory. The early failure of the wooden stringers was due largely to rotting and crushing at the ends, where they rested on the floorbeams. This rotting and the liability to fire were the reasons for the substitution.

Double-Truss Construction of the Through Spans

The two through-truss spans are most remarkable for their duplex construction. Each side or truss is made up of two identically equal trusses set close, side by side. Why this was necessary may be gathered from the fact that in 1870 the 400-ft. span was "the longest truss weight and take a true half-share of the floor load. The former requirement was met by erecting the two trusses separately:

> **The trusses on either side of the roadway are now securely connected by bolts and struts; but before being thus connected each was allowed to support its own weight, and assume its natural camber, uninfluenced by any connection with its neighbor. By this precaution the possibility of undue strains from inaccuracy of workmanship was avoided.**
>
> **It is of interest to note that when thus swung independently no perceptible difference could be observed in the camber of the four trusses, which, while supporting each its own weight, were bolted together without reaming or chipping.**

The connection by cast-iron separator "struts" is indicated in Figs. 7 and 8. In the bottom chord it occurs at the ends only, but the floorbeam connections also serve as spacers.

The second problem, equal division of the floor loads, was solved by help of the truss-rod construction of the double 12-in. I-floorbeams. The pair of I's was extended under both trusses and connected to both by similar sets of hangers; and the trussing eye-bars were connected to the I-beams in the center line between the two trusses.

This method of connection appears to have sufficed for equal live-load distribution so far as the major members of the trusses are concerned; the truss separators would help to prevent unequal deflection. But at the subhangers the equal distribution of the single panel load to the hanger bars was not secured, apparently. At any rate a system of equalizer levers was put in at these points 20 years ago, which divides the load equally among the individual hanger bars of the two trusses.

A few details of the truss construction are reproduced in Fig. 8. The general drawing, Fig. 7, shows the form of the portal and sway systems—all cast iron.

A prominent feature of the through spans is found in the eye-bars. The thinnest, which occur in the second panel, are only $\frac{3}{4}\frac{1}{2}$ in. thick in the body (all the bars are 6 in. wide. The heads of the bars are thickened, however, so that they possess lower bearing pressure and better resistance to dishing in the head than might be expected from the dimensions of the bars. The heads were forged separately and welded to the body of the bar.

The stiff diagonals in the middle panel are supplemented by eye-bars extending alongside. This provides for counter stresses. Fig. 7 does not show these counter

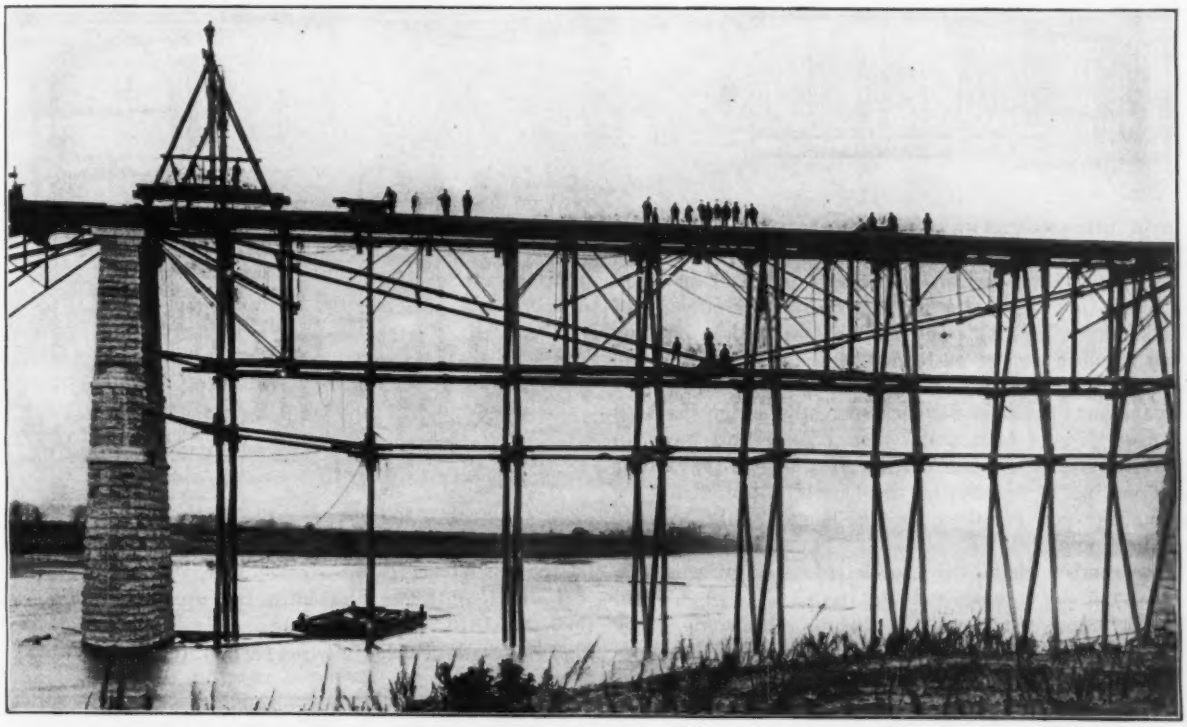


FIG. 5. ERECTION OF ONE OF THE FINK DECK SPANS OF THE LOUISVILLE BRIDGE
Reproduction of an 1869 photograph

ties, which indicates the possibility that they were added after the original plans had been drawn.

The only alterations made in these two spans since construction were installing hanger equalizers and providing steel I-beam stringers. Some adjustment of the expansion rollers was required, when these were found to have grooved into their bed plates and rusted fast.

Loads and Stresses; Material

The bridge was designed to carry a rolling load of 2600 lb. per lin.ft. The present-day loads are probably somewhat more than 50% higher. However, the original unit stresses were low, and this accounts for the fact that the bridge has not been fatally overloaded before this. Concerning the unit stresses, Mr. Fink said:

> **The factor of safety in the cast-iron chords is from 6 to 7, and in the wrought-iron braces from 5 to 6, by Hodgkinson's formula.**
>
> **The strain in the wrought-iron tension members is varied according to their position and duty; for example, the suspension and small truss-bars of the channel spans, which are subjected to a maximum load at the passage of each train, have with this load [2600 lb. per lin.ft.] a strain of from 7000 to 8000 lb. per sq.in.; while the bottom chords of these spans, and the main system of the suspension trusses, which rarely, if ever, are subjected to the calculated maximum strain, are proportioned for a strain of 12,000 lb. per sq.in. The other tension members of the bridge are proportioned for intermediate strains, 7000 lb. being the least and 12,000 lb. the greatest strain with a full load.**

The iron in the bridge (other than cast) was wrought iron of "not less than 60,000 lb. per sq.in. breaking strength."

On this point of strength, however, interesting figures were obtained by J. C. Bland, Engineer of Bridges, Pennsylvania Lines West of Pittsburgh, in connection with an analysis of the entire bridge in 1901, made to fix the maximum loading that could be used. Of the 6-in. eye-bars forming the lower chord of the trussed floorbeams of the through spans, four were selected at random, taken out, and subjected to full-size test. The results were:

Test	Span	Elastic Limit Lb. per sq.In.	Maximum Strength, Lb. per Sq.In.
1	370 ft.	29,580	46,340
2	370 ft.	30,590	45,880
3	400 ft.	33,320	34,835
4	400 ft.	34,157	42,824

Note. Tests 1, 2 and 4 broke in the head. Test 3 broke in the body of the bar, 12¼ in. from pin center.

Deflection and Camber

All trusses of the bridge were cambered, the amount of erection camber being such as to bring each span into straight condition under full live-load. The flexibility of the Fink trusses appears to have been rather high, as might be judged from their shallow proportions and the slight inclination of the longest truss eye-bars. The longest Fink spans, 245 ft. 5 in. in length, were tested under a train of four locomotives weighing 200 tons; the center deflection was 1¾ in. and the quarter-point deflection 1¼ in.

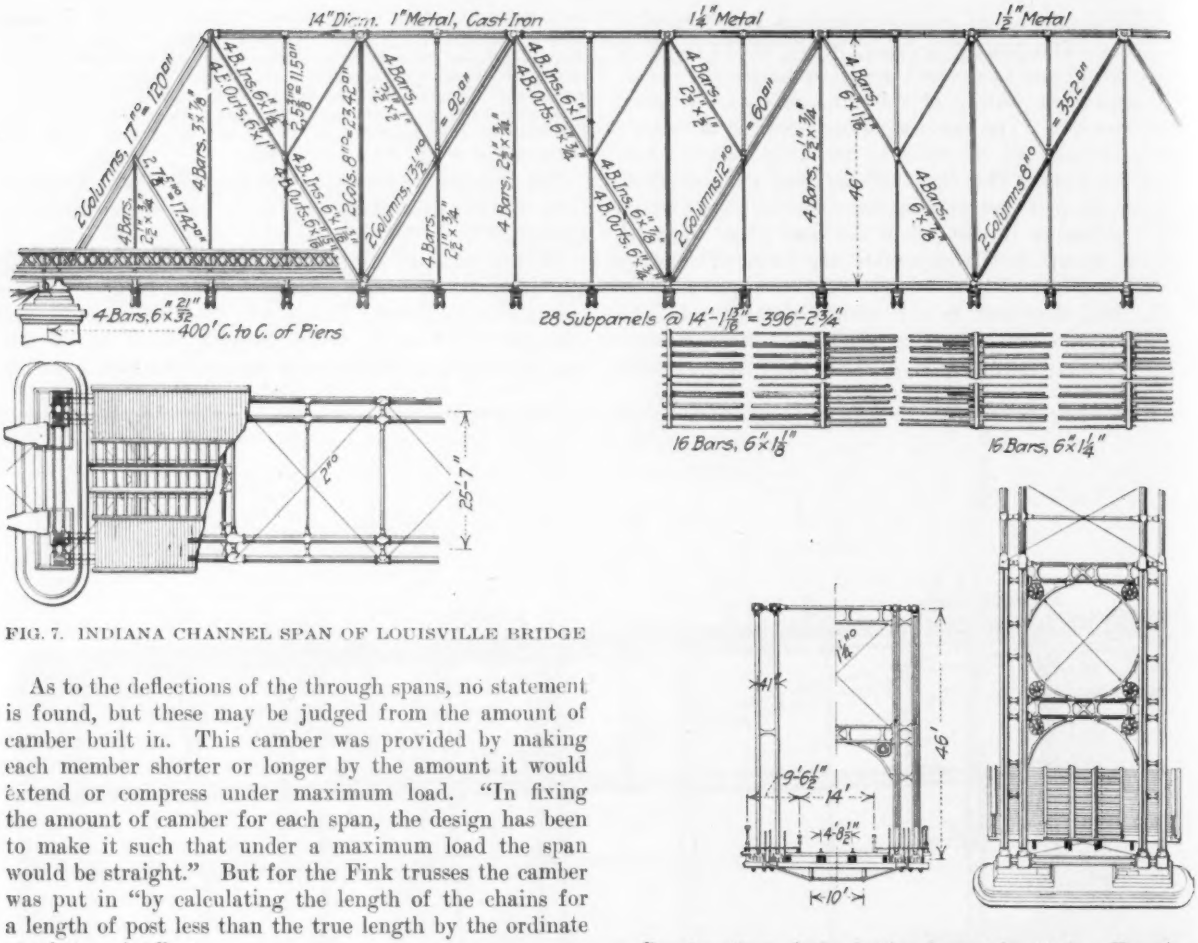


FIG. 7. INDIANA CHANNEL SPAN OF LOUISVILLE BRIDGE

As to the deflections of the through spans, no statement is found, but these may be judged from the amount of camber built in. This camber was provided by making each member shorter or longer by the amount it would extend or compress under maximum load. "In fixing the amount of camber for each span, the design has been to make it such that under a maximum load the span would be straight." But for the Fink trusses the camber was put in "by calculating the length of the chains for a length of post less than the true length by the ordinate at that point."

The camber of the two channel spans is given as 2½ in. for the 400-ft. span and 3¼ in. for the 370-ft. span. The difference presumably is due to settlement of the falsework.

Construction of the bridge began in 1867. Erection of the superstructure was started May, 1868, and finished Feb. 1, 1870. The first train ran over the bridge on Feb. 24, 1870. This was considerably behind time, due to two reasons—delay on the part of the masonry con-

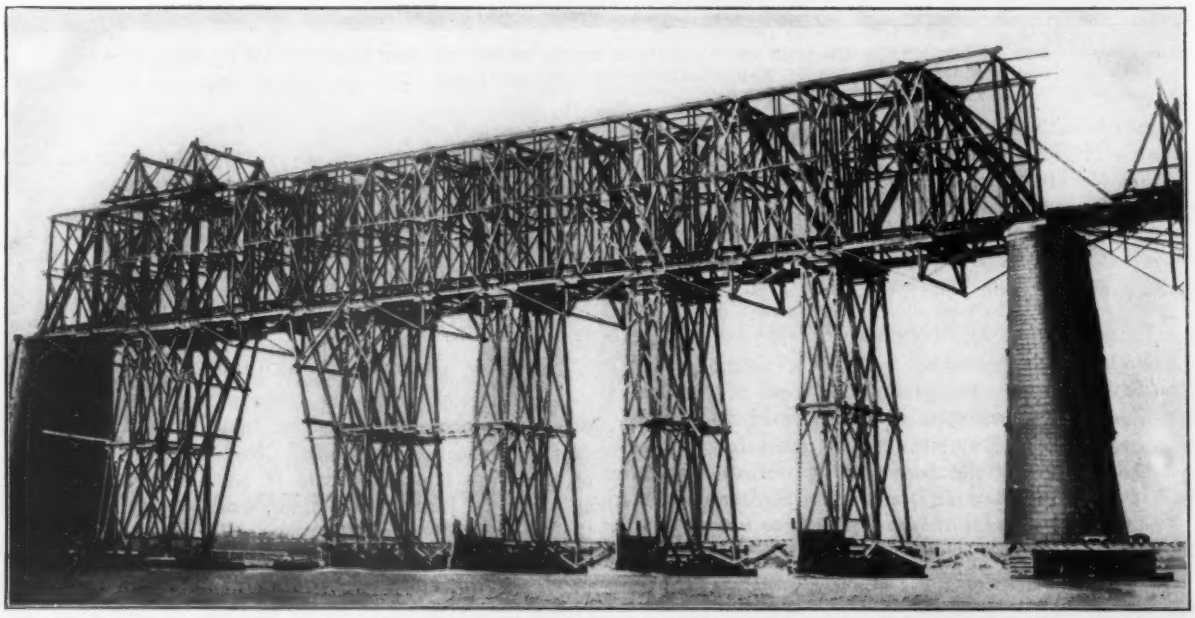


FIG. 6. FALSEWORK AND TRAVELING CRANES USED IN ERECTING THE 400-FT. THROUGH SPAN

ractor (which led to the engineers completing the work by force account) and the loss of the last steel span to be erected. The construction work is well portrayed by the original views, Figs. 5 and 6.

Construction of the Bridge

The piers all rest directly on the river bedrock. A working track supported on 6-ft. square cribs 36 to 40 ft. apart, set diagonally to the current, was bolted down into wedge fastenings in the rock by 4-in. bolts. All masonry and material were handled on this track.

Erection of the Fink spans was managed with the very simple falsework shown in Fig. 5. An elaborate enveloping falsework and scaffolding, however, was required for the through spans. Upper-chord traveling cranes, as can be seen in the photograph, handled the material for these spans.

During the life of the bridge it was painted with one coat in 1877, one coat in 1889 and one coat in 1901, or only three coats during the 47 years from its completion up to date. All these coats (subsequent to the erection coat) consisted of straight red lead and oil, without coloring. The oil was bought raw and boiled on the job.

The last coat of paint was in splendid condition when 11 or 12 years old, which agreed with the previous experience that repainting at 10- or 12-year intervals kept the bridge in perfect shape without pitting, flaking or other defects. However, the repainting due about 1913 was omitted because plans for reconstruction were under way. The result is that, although the paint in general looks good (though rather thin), there are occasional

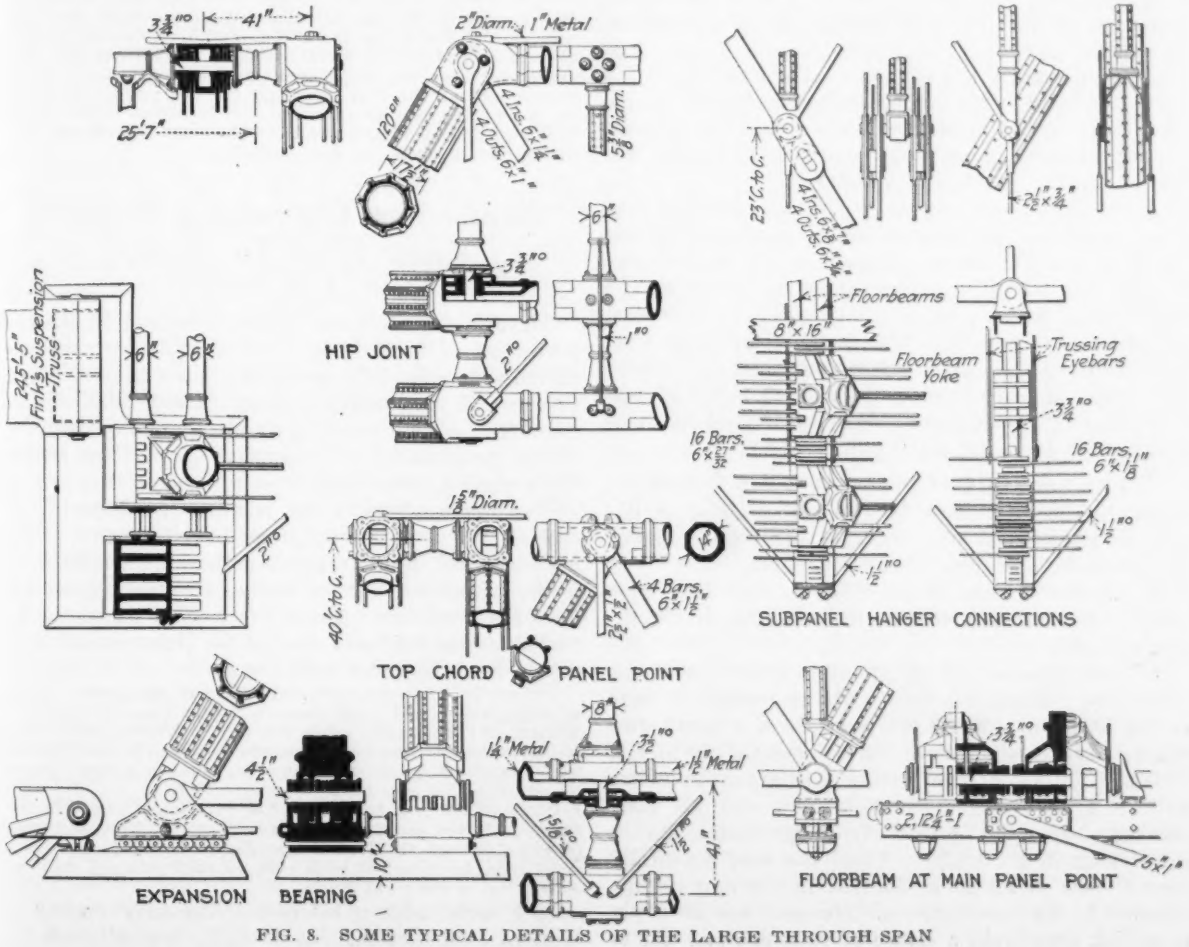


FIG. 8. SOME TYPICAL DETAILS OF THE LARGE THROUGH SPAN

A few figures of weight and cost may be of interest. For the entire bridge, 5261½ ft. long, the total iron weight is 8,869,000 lb., comprising the following items: Cast iron, 4,317,000 lb.; wrought iron, 3,245,000 lb.; column iron, 914,000 lb.; beam iron, 393,000 lb. In addition, the amount of timber in rail joists and cross-ties comprises 291,000 and 260,000 ft. b.m. The weights of four lengths of spans are as given in Table 1. The costs of the same span lengths are expressed in Table 2 and the construction cost of the whole bridge, $1,653,586.86, is itemized in Table 3. The original estimate was about 10% lower.

TABLE 1

Span Ft.	Span In.	Cast Iron	Wrought Iron	Column Iron	Beam Iron	Total
146	10½	101,453	63,904	6,320	.....	171,677
242	....	213,000	180,000	37,200	.....	430,000
368	....	480,953	350,928	228,473	60,694	1,121,048
396	2½	570,585	478,022	280,920	75,938	1,405,465

TABLE 2

Span Ft.	Span In.	Ironwork	Framing and Raising Falsework	Raising Span
146	10½	$11,758	$450	$700
242	....	30,056	2,500	2,000
368	....	87,764	5,500	4,880
396	2½	107,995	8,500	10,070

TABLE 3

Foundation	$615,702.52
Superstructure materials	703,067.40
Raising	114,041.75
Scaffolding	76,292.79
Tools and rigging	11,135.13
Painting	12,566.72
Engineering ($45,560.97) and other expenses	120,780.55

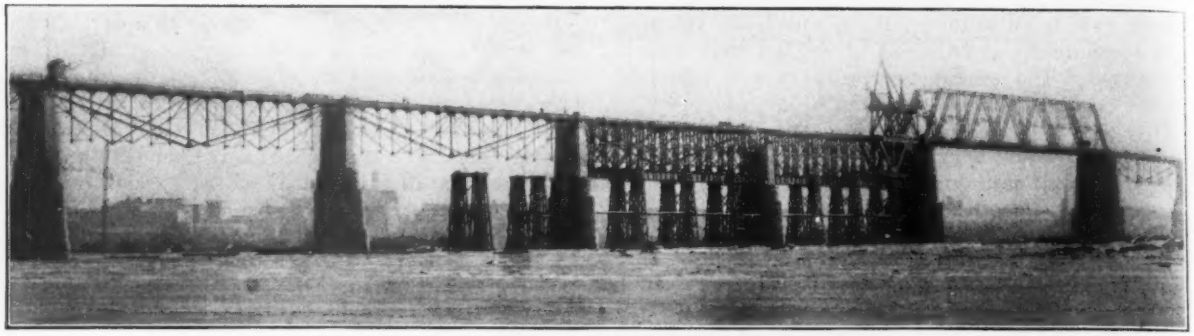


FIG. 9. PART OF THE LOUISVILLE BRIDGE AS IT APPEARS TODAY
View toward Louisville, showing Kentucky Channel span

places where flaking patches indicate that the protection is about at an end.

A most unusual proceeding was the painting of the inside of all Phœnix column members in the bridge, which was done a number of years ago. Some interior rusting of these columns had been noticed or was suspected, and the painting was decided on.

A force pump was used as the painting tool. A hose from the pump led to a perforated nozzle, which was inserted into the column through a hole at the top, lowered and raised up as the spraying proceeded. The paint was practically in brush condition. It sprayed perfectly. The pressure being high, it tended to wash the metal and took off a certain amount of rust, which was caught with the excess paint in a tub at the bottom. This was an iron oxide paint. It is still in good condition and has not lost color materially.

Bridge Shows Great Durability; Few Repairs

This bridge has existed for its entire period of life without any trouble with rivets or any replacement of rivets—an unusual experience with riveted work.

A peculiar feature of the rivets is that they were "beveled for half their length" to enable the rivet to fill the hole when upset.

All other elements of the structure have been almost as durable. There has been a slight amount of wear of the lateral rods where the two rods of a panel cross and rub on each other under the movement of the bridge. This and the loss of free movement at expansion rollers (of the through span; the deck spans slide on plate bearings) are virtually the only things that might be called wear in the bridge. There has been practically no pin wear so far as is observed in the pins already removed in the reconstruction. However, one main pin in a Fink span broke a couple of years ago and had to be replaced.

The pier masonry was repainted 18 years ago. The masonry is today in perfectly good condition and is used for the new bridge, the piers being cut down to suit.

The bridge was erected by the forces of the Louisville Bridge Co. (the owner). The ironwork was fabricated by the Louisville Bridge and Iron Co. The masonry contract was taken over by the company and carried through to completion by force account. Concerning the men in responsible charge of the work, Mr. Fink after commending F. W. Vaughan, Principal Assistant Engineer, says:

> Mr. Vaughan was ably seconded by Mr. Edwin Thacher, assistant engineer in charge of the instrumental work, and Messrs. Patrick Flannery and M. J. O'Connor, in charge of the masonry construction, and Mr. Henry Bolla, in charge of the erection of the superstructure—a most difficult task well performed. The Louisville Bridge and Iron Co., contractors for the superstructure, have faithfully carried out the plans furnished them, and great credit is due to Mr. E. Benjamin, superintendent for that company, for the perfect execution of this work. The wrought iron was furnished to the Louisville Bridge and Iron Co. by the Ohio Falls Iron Works, and satisfactorily stood the test applied.

Should Not Engineering Teachers Know How To Teach?

By A. M. Shaw*

There is a general and insistent demand for an improvement in both the intellectual equipment and the ethical standards of the members of the engineering profession and particularly of those seeking admission to its ranks. A most encouraging feature of this agitation is that the demand for improvement springs from within the profession rather than from without.

The means advocated for securing the improvement desired cover a wide range, from the elimination of the inefficient and those lacking in enthusiasm for the work to the extension of the university courses in engineering from the usual four years to five or even six years. In addressing the freshman class of the University of Minnesota, Dean Shenehon said[1]:

> Primarily, I want to congratulate you upon your choice of a profession and upon your chance in life. It is only a chance, an opportunity thus far . . . Undertaking work in the College of Engineering shows courage, for only strong men knowingly enter here where the portion is man's work. No mollycoddles may hope to prosper here. . . . I do not hesitate to tell you frankly at the outset that the task before you is not child's play nor boy's work; because if any of you does not thrill at the prospect of a stiff fight or a swift race, he is not of such stuff as engineers are made of—he is not in the right group.

In a recent address before the Engineers' Society of Western Pennsylvania,[2] Dr. J. A. L. Waddell said:

> For 30 years the speaker has been preaching the necessity of five-year courses in civil engineering. As long ago as that there was a real need for more time in order to learn the fundamentals of the general science or art of engineering as then known and understood; but since then the amount of knowledge concerning all the numerous branches thereof has increased many fold, and, consequently, the truly necessary things that an engineering student must learn today in order to obtain a proper technical training cannot be taught him in a four-year course, even if there be 11 working months in the year—as there should be when fieldwork is properly covered.
>
> In order that technical education may keep pace with engineering progress, one of two things must be done—either the engineering curricula in the universities and technical schools must be lengthened, or else they must be modi-

*Consulting Engineer, Hibernia Building, New Orleans, La.

[1] "Addresses to Engineering Students," published by Waddell & Harrington, Kansas City, Mo.

[2] "Proceedings" of the Society, Vol. 32, p. 467.

fied so as to cut out some of the more advanced courses, in order to permit more thorough instruction in the remaining ones and the addition of many culture studies, leaving those students who desire more complete technical education to obtain it in postgraduate engineering schools. In any case we need more postgraduate technical courses than are now available for the youth of the United States.

Most writers on the subject agree with Dr. Waddell that the time given to preparation must be increased, either by extending the initial course or by postgraduate work, it being generally conceded that in the better schools of the country no material addition to the amount of work covered during the four-year course may be undertaken.

The writer agrees with this position in its main features; but pending such a time as it may be possible to extend the preparation of the embryo engineer by lengthening his time in school, still further thought may be given to gaining greater efficiency of the student (and thereby increase his working capacity) within the present prescribed limit of four years.

It appears to the writer that this may best be done by improving his habits of study. No originality is claimed for this idea; in fact, it is emphasized in most of the writings on engineering education, though little has been written on how this may be done. There can be no doubt that if all students were to enter on their freshman year with well-established habits of study and a thorough knowledge of how to study and how to use to the best advantage every hour of the day, much work could be added to the four-year course without exceeding the capacity of the average student.

During the high-school period, students should be trained in the proper use of their time; but the haphazard methods of study, recreation and rest followed by the average university student would indicate that either proper habits were not acquired in their high-school days or that these habits were dropped on entering the university. To secure the greatest good, these correct habits should be established as early as practicable. This can only be done by making a close study of the individual students and by directing their efforts in minute detail during the first few months.

Is the ordinary college or university faculty equipped for such study and supervision? There is no disposition on the part of the writer to question the high aims, the ability nor the excellent work being done by the large majority of engineers who are engaged in teaching. Their devotion to the work which they have undertaken and the conscientious manner in which it is being performed command the respect of every engineer who is practicing in other branches of the profession.

This admiration does not necessarily blind one, however, to the shortcomings of the engineering faculties as ordinarily organized. Many of our schools employ the very best talent that can be obtained to place at the head of their engineering courses, and the other members of the faculty who are engaged in teaching the more advanced studies are among the best in their special lines; but how about the men who first come in contact with the freshman student? These instructors and assistant professors are often brilliant men who have been employed as the result of exceptional work as students, devotion to their alma mater or popularity with the student body—all excellent qualities, but none of them demonstrative of ability to train other minds or to impart information to them in the most efficient manner.

Engineers exercise the utmost care in writing specifications for materials of construction, but the same care is not used in writing specifications for those who are to direct the earlier efforts of our engineering students. Here is a fair sample of such specifications:

> Wanted—A technical graduate for the position of instructor in the course of civil engineering in the X University. Applicants with one year or more experience will be given the preference. Salary, $80 per month.

The foregoing is not an exact quotation, but it would not require a very extensive search through the back files of any engineering journal to find something quite similar to it.

A teacher should not only possess the information that he desires to impart to others, but he should also be a master of the art (and it is an art) of presenting that information in such a manner that it may be acquired most readily by even a mediocre mind; or better yet, he should be able so to train that mind that it may gather information readily from all the available sources open to it.

In nearly every other line in which teaching of any sort is done, special attention is given to the training of those who are to teach. Directors and secretaries of the Young Men's Christian Association, public-school teachers and even Sunday-school teachers attend special training schools in which they are taught not only what to teach, but how to teach. In most states one must hold a certificate from an approved normal school or at least pass a satisfactory examination in pedagogy and allied subjects in order to teach in public schools of any grade. Those who teach engineering, however, learn the art of teaching by practical experiment on the student material under their charge.

The objection may be made that to insist on this additional preparation of young teachers of engineering would entail an additional expense that many of our schools are in no position to carry and would also keep out of the profession many deserving young men who, under the present plan, are able to obtain remunerative (?) employment immediately after graduation. Undoubtedly such a requirement would make necessary higher salaries for the lower-grade instructors and professors; but a readjustment of salaries would appear to be justified if better training of the student in the early part of his course could be thereby assured.

It hardly appears practicable for teachers of engineering subjects to secure in any of the existing state normal schools the special training advocated. The atmosphere would not be congenial, and the courses, as usually arranged, would not be readily adaptable to the needs of such teachers. The need might better be met by the establishment of a special course in some one or more of the larger engineering schools. A postgraduate course for teachers could be arranged, which could include a reasonable amount of special engineering studies. A graduate engineer should be able to add materially to his training along other lines at the same time that he takes special training for teaching.

Some of the wealthy friends of higher education might find in such a school a worthy object for an endowment of such proportions that a school could be established which would be able to give the best training possible to the young men who are to direct and advise the students of our engineering schools during the character and habit-forming period of their course.

Double-Track Work on a Busy Section of the Erie Railroad

SYNOPSIS—This improvement includes grade reduction and some relocation, and a new reinforced-concrete trestle across the Kankakee River. Excavation done by steam shovels. Material distributed mainly by dump-car trains, but on one section there was the unusual method of the steam shovels casting the material directly into place.

The 37 miles of double-tracking now in progress on the Erie R.R. between Lomax and Griffith, Ind. (30 miles east of Chicago), will give this road a double-track main line all the way between New York and Chicago (989 miles), except for about 20 miles of single track near Jamestown, N. Y. On this new double-track section the passing or relief sidings are made long enough for 100-car trains. It is of interest to note that from Griffith to Hammond (9 miles), the parallel single-track lines of the Erie R.R. and the Chesapeake & Ohio Ry. (on adjacent right-of-way) are operated by joint agreement as a double-track line. This saves the cost of double-tracking either of the two roads.

Although the country is flat, some grade reduction was included in the improvement, so that between Marion and Chicago (269 miles) the maximum grades will be 0.2% westbound and 0.3% eastbound, instead of 0.5% in each direction. The sharpest curves on the improved line are of 1° 50′. The flat country along the new double-track work was formerly swampy (the line traversing the great Kankakee marsh), but it has now been largely reclaimed by drainage works. There are only a few small towns along this portion of the line.

The profile was improved by raising fills in sags and lowering summit cuts, and the excavation approximately balanced the fill. Where small changes of grade were required in the existing track, these were introduced in ballasting, without disturbing the roadbed. All material for fill was obtained from borrow pits and cuts along the work. Oil pipe lines (pumping mains) 8, 10 and 12 in. in diameter are laid along the right-of-way. As a rule these were not affected by the borrow-pit excavation, but at some points it was necessary to shift them. The work includes about 1,200,000 yd. of excavation, 10,000 yd. of concrete for bridges and substructures and 350 tons of steel bridgework.

For 11 miles, a new double-track line was built with its center at 49.5 ft. from that of the original track, and the latter track was abandoned. This was done to get the desired grades without interfering with operated track. For 5 miles, the second track was built with its center line 52 ft. from that of the old track, and the latter was not changed. This gave the desired grades eastbound and westbound without disturbing the old track, which is to be the westbound track. At three points temporary detours were built, each about 1½ miles in length, for operation during construction. Fig. 1 shows the new second track built separately from the original line. It shows also one of the temporary detours or "run-around" lines built to carry traffic where the old single-track fill was being enlarged for double track.

This improvement work, which represents a total cost of about $2,100,000, was practically completed by the end of 1916. The general contract was let to the Robert Grace Construction Co., of Chicago, which has sublet only the 11-mile stretch of fill near Lomax (noted below). The steel bridge erection is being done by the railway company's forces. The construction is in charge of C. R. Hughes, District Engineer, with three Resident Engineers: M. W. Manz, W. A. Scott and F. E. Welsh. Maintenance of operated tracks is under F. D. Lakin, Division Engineer. Bridgework is under F. A. Howard, Engineer of Bridges. The entire work is under the direction of R. S. Parsons, Chief Engineer, and R. C. Falconer, Assistant Chief Engineer, of the Erie R.R.

Earthwork Methods

The new fills were made by dumping from temporary trestles. The trestles had 15-ft. spans with four-post bents in which all posts were battered, two meeting under each rail. The bents had round posts and squared caps and sills. The widening of old fills was done by side-dumping from the main track. Where the old fill was both raised and widened (and traffic diverted), the material dumped was thrown back under the construction track, raising the latter until the desired height was obtained.

All the excavation (for cuts and borrow pits) was done by steam shovels, and in most of the work the material was handled by standard-gage equipment, using 12-yd. dump-cars (with average load of 10 yd.). When operated over the main track, these cars were handled in long trains, in order to reduce interference with traffic. The trains consisted of about 40 cars with three locomotives, or 30 cars with two locomotives. A Jordan air-operated spreader-car was attached to the rear of the train. The cars were equipped for dumping by air, but as a rule they were dumped by means of a lever or pole, owing partly to lack of sufficient air pressure. Most of the locomotives were owned by the contractors and some were leased from the railway.

At the long and deep summit cut near Palmer (a new double-track cut) two 70- and 75-ton steam shovels with

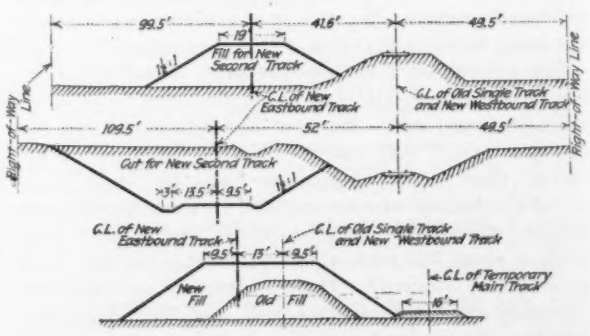


FIG. 1. TYPICAL CROSS-SECTIONS OF WIDENING FOR DOUBLE-TRACK ON THE ERIE R.R. IN INDIANA

The two upper sections show the construction with new fill and cut for the second track. The bottom section shows the enlargement of the old fill, with temporary runaround track

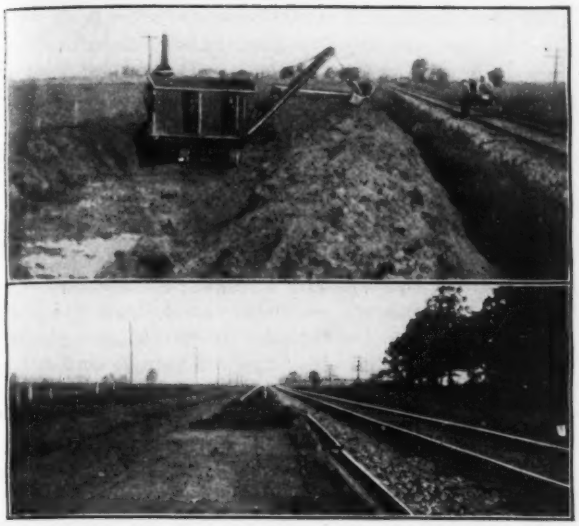


FIG. 2. WIDENING FILL BY DIRECT CASTING; ERIE R.R.

The upper view shows one of the revolving shovels casting material directly from the borrow pit to the fill. This is near Kouts, Ind. The lower view shows a stretch of the completed subgrade (looking west), with the old single track at the right and part of the new second track laid

2½-yd. buckets were used, working from opposite ends of the cut. One was served by narrow-gage equipment (36-in. gage) with trains of 4-yd. dump-cars and four-wheel dinkey locomotives. The other had standard-gage equipment. Both built new double-track fills by dumping from trestles. Small spreader-cars were used with the narrow-gage trains. There was a small amount of scraper work, mainly for the approaches at highway crossings. Much of the excavation was in tough, sticky clay. This did not dump well, and sometimes carried a 12-yd. car off its frames or trucks or carried a narrow-gage 4-yd. car bodily over the dump. The locomotive cranes employed for handling concrete material and driving piles were found useful in such emergencies. This material also caused occasional slides in the fill in wet weather.

The culverts were extended to the new slope lines regardless of slides. A sink-hole or deep pocket of wet, black, vegetable soil is crossed near Crown Point, Ind., and the old fill has to be raised periodically on account of the continual settlement. Although the new fill (against the old one) is light, its weight caused the ground to rise in a wave about 100 ft. from the track and in some places to a height of 15 ft. above the level of the top of the fill. At this point a drainage ditch 3 ft. wide on the bottom and 2 ft. deep, with slopes of 1½:1, was dug along the side of the right-of-way. This was excavated by a small revolving steam shovel with ½-yd. bucket, which was served by narrow-gage dump-cars and dinkeys.

The allowance for shrinkage of fill is 10% as a rule, but sometimes 15%. In widening fills the plan generally adopted was to make a sloping top, level with subgrade on the inner side and 10% higher at the outer side, as it was thought the settlement would be less over the slope of the old fill. A plan proposed by W. M. Dawley, Assistant Engineer, was to use a steam roller to roll the subgrade to take out the 10% excess height, and then to oil the surface so as to exclude frost and so prevent heaving.

The fill is mainly 6 to 30 ft. high, with a maximum height of 35 ft. The maximum depth of excavation for new cuts is 22 ft., but the lowering of grade in the summit cut will give a total depth of nearly 30 ft. for this cut. Where the fill is light, the surface of the old slope is not stripped or roughened to make a bond with the new material. In widening fills of over 10 ft., however, the old slope is required to be cleared and then formed in steps or benches. The width of roadbed on the old single-track fill is usually 19 ft. and is increased to 32 ft. for double track, with tracks spaced 13 ft. c. to c.

All new fills over 5 ft. in height were ballasted with slag or cinders, 12 in. deep under the ties. After a year's service, when settlement has ceased, the regular stone ballast will be laid upon this bed of sub-ballast. Cinders are preferred as they form a dense blanket, while mud will work up through the slag; but a sufficient supply of cinders was not available.

The rather unusual method of casting material directly from side borrow pits into the fill by steam shovels, thus eliminating all hauling, was employed for the first 11 miles west from Lomax. Here the new fill (deposited against the old single-track fill) averaged 5 to 7 ft. in height, and totaled about 130,000 cu.yd. of material. The subcontractor for this stretch of fill was F. J. Mann, of Wauwatosa, Wis., and he saw the possibility of doing the work cheaply in this way. A revolving shovel with ⅞-yd. bucket and 15-ft. boom did most of the work, and its highest record was 18,520 yd. in 25 shifts of 10 hr. each. The fill was leveled by means of teams with slip scrapers and road graders.

This fill was commenced in April, 1916, and it was estimated that with an average progress of 912 yd. per day it would be completed in August, before the fall period of bad weather. The progress, however, did not come up to the requirements, and the engineers ordered a second machine installed, as with wet weather this method could not be operated. This would have rendered unavailable the borrow-pit sites already purchased by the company along the right-of-way, and it would have been necessary to haul in material, which would have added to the cost and involved occupation of the main track by work trains. The second machine was of the same type and size, but with a boom only 12 ft. long. In this way the work was completed by Oct. 15, in time to escape a period of heavy rains. Fig. 2 shows this fill in progress.

Bridges and Concrete Trestles

The most important structures are two reinforced-concrete trestles crossing the two channels of the Kankakee River. These are 322 and 162 ft. long, separated by 1100 ft. of fill, which replaces an old pile trestle. The bents are of Massey precast concrete piles, 25 ft. long, spaced 30 in. c. to c., and the bents are 16 ft. c. to c. The top stratum of soil is sand. Below this is a mixture of sand, gravel and clay, which makes very hard driving and in which the water jet is of little or no use. The piles were driven by a Vulcan 5-ton steam hammer. At first a lighter Vulcan hammer was used, but this was not powerful enough for the work, and it was necessary to cut the heads of some piles. For this the concrete was broken with a sledge and a chisel, and the bars were cut with a hacksaw. With the heavy ham-

mer the piles are driven to the full depth and no cutting is necessary.

Each bent has a cap cast upon it, and the concrete deck is cast in place upon the caps. At intervals, where an expansion joint occurs in the deck, there is a double bent with wide cap. The fixed end of one slab is secured to the cap by dowel rods, while the free end of the other rests on top of the cap. All the caps have very heavy steel reinforcement. The abutments are so made as to serve as piers in case it should be necessary to give increased waterway by additional spans.

The deck is a flat slab with curb walls to retain the ballast, and is built in lengths of 64 to 80 ft., separated by expansion joints. This deck really consists of 16-ft. I-beam spans embedded in concrete, each span having a series of I-beams grouped under each rail, with old rails laid outside of the beams. There are no bars, but

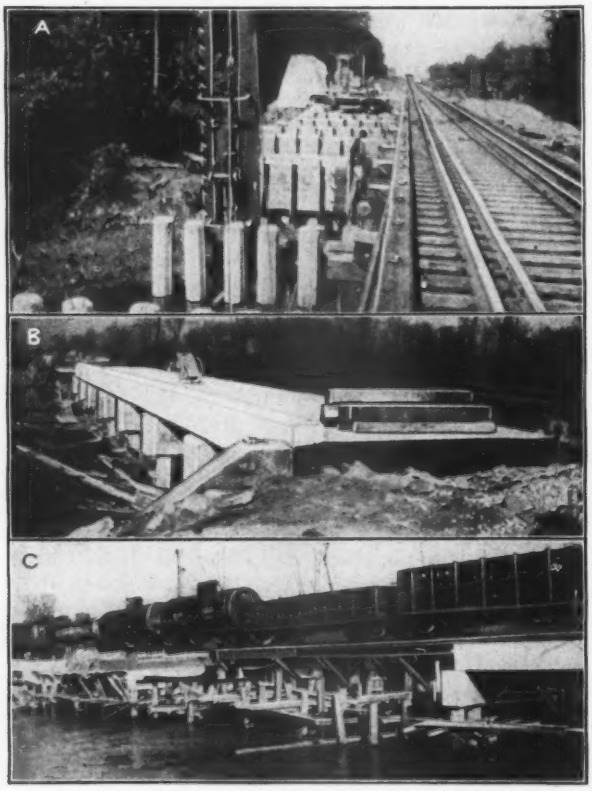


FIG. 3. REINFORCED-CONCRETE TRESTLE OVER THE KANKAKEE RIVER; ERIE R.R.

A—Driving concrete piles for new trestle alongside old timber trestle. B—Section of completed deck. C—New concrete trestle being built alongside old timber trestle. The open space is for a girder span at center of channel

sheets of welded woven-wire fabric are placed under the I-beams.

In each one-track span there are four 1½-in. drainage holes, and in order to shed water from the central longitudinal joint a small ridge is built along the inner edge. An unusual feature is the use of 1½-in. galvanized pipe sleeves in the drainage holes, with their lower ends projecting 2 in. below the concrete. Their purpose is to prevent damage to the concrete by the brine which drips from refrigerator cars and may be washed to the drainholes.

This double-track trestle was built in two longitudinal sections. The first of these was alongside the original track and when completed traffic was diverted to it, while the old line was torn up and the second half of the trestle built. The caps are built with a halved joint at the middle, so as to connect the two sections of the trestle and to distribute the load over the piles.

At the middle of the trestle over the main channel of the river there is an opening 38 ft. wide to pass dredges and drift. This has concrete piers carrying a plate-girder open-floor deck span.

There are few other important structures. Culverts are mainly of concrete with I-beams and rails embedded in the roof. Existing cast-iron pipe culverts (of ordinary water pipe) are extended to the length required for the widened fill. Drainage ditches are crossed by open-floor plate-girder decks or through spans of 24 to 50 ft., generally with three girders. The law requires that for such crossings the railways must install bridges that can be removed to allow the passage of dredges.

Bridges over highways have plate-girder spans with a solid steel deck waterproofed with a course of brick laid in an asphaltic composition. Some highway bridges over the railway are of interest in having concrete abutments, bents and slab side spans (over the slopes of the cut), with plate-girder spans over the tracks. These steel spans have plank floors.

The concrete is made with stone in preference to gravel and for this a hard local limestone is used. Gravel concrete is used in some cases, however. Wood forms are employed. Exposed surfaces are well rubbed with cement bricks and water. In all concrete structures the date (year) of construction is marked in recessed figures, and the contractor is required to place a metal nameplate or label. This is a small oval plate of bronze, bearing the contractor's name and the date of construction.

The concreting plant at the Kankakee River bridge has a set of stationary bins from which material is wheeled to a drum mixer of 15 cu.ft. capacity, which is kept near the work. From this the concrete is distributed by wheeled carts. For other work a portable concreting outfit is used. This consists of a flat-car having at one end a low hopper with spout to the boot of an inclined bucket elevator, which discharges into an overhead bin for aggregate. A chute from this delivers the material to a ½-yd. mixer at the other end of the car. The aggregate is delivered from cars to the hopper by means of a locomotive crane operating a grab bucket.

Locomotive cranes are used for piledriving, with swinging leads suspended from the head of the boom, and also for pulling the sheetpiling of cofferdams. Steel sheeting was used at the piers for the steel spans of the Kankakee River bridge, and where this was too twisted or jammed to be pulled out it was cut away by oxyacetylene cutting torches.

Track, Work Trains, Etc.

Ballasting and trackwork was done by the general contractor on a force-account basis. Steel bridge erection was done by the bridge gangs of the railway's construction department. The new tracks are laid with 100-lb. rails of the A. R. A. (A-type) section, on 8½-ft. creosoted red-oak ties, with broken-stone ballast 12 in. deep under the ties. Sub-ballast is used on new fills, as noted above. Tieplates are laid on all ties on curves of over 1½°. It is of interest to note that the splice bars are

oiled, as a protection against corrosion due to brine dripping from refrigerator cars.

The stone ballast used on this road is unusually coarse, the specified size being from 1 to 2½ in. On this work the stone is distributed from steel hopper-bottom ore-cars with transverse hopper doors. These were handled in trains of 30 cars, moving at very low speed. Only one car was unloaded at a time, two or three ties being laid across the rails in front of its rear truck so as to plow off the stone as it flowed from the car. Very little trouble was experienced in leveling the material in this way (although it is not generally regarded with approval) and derailments due to it were of rare occurrence.

Progress records are kept by a series of profiles or diagrams showing the grading, concreting, dressing of roadbed, ballasting, tracklaying, etc., and showing also the supply of rails, ties and other material. These are graduated horizontally for days and vertically for cubic yards, lineal feet or other measurement. A straight line drawn in advance upon the diagram shows the progress required for the completion of the work within the desired time, and the plotted progress record shows how nearly the work approximated to the requirement. In this way there is a graphic record of the actual and relative progress.

The traffic on this part of the line is heavy, the daily number of trains in both directions averaging 40 (including passenger and freight regular and extra trains); therefore, work trains operating on main track cannot make much progress. The main track is occupied as little as possible for construction work, but has to be used by the dump-car trains in the first widening of fills by side dumping. Construction tracks are then laid as soon as the increased width permits. The movements of the work trains on the main track are controlled by the telegraph operators, working under instructions from the dispatcher.

Exploring a Deep Well by Gas Seal at Saratoga Springs, N. Y.*

By C. G. Anthony†

In 1885 the well now known as Hathorn No. 1 was drilled at Saratoga, N. Y. It is a 3-in. diamond drill bore, 1006 ft. deep. In 1911, when the State of New York took possession of the Saratoga springs through condemnation proceedings, this well was not flowing. As this water, with the exception of the Congress water, was the most famous of all Saratoga's mineral waters, the state officials deemed it advisable to do everything possible to restore the water to the public. An extensive survey was made of the bore, and the completed log of this well is only one of many interesting and peculiar problems to be found in this valley of hydraulic wonders.

A 1¼-in. pipe was placed in the 3-in. diamond drill, with two rubber seals on the pipe at the bottom and 5 ft. apart. The bottom of the pipe was plugged, and the section of pipe between the seals was perforated so that the water would pass into the 1¼-in. pipe between the seals. The seals were slightly larger than the 3-in. diamond bore. By adding lengths of 1¼-in. pipe and pushing the seals down, the seals could be placed at any point in the well; and by means of a pump, water was taken from various points in the well and analyzed. This survey gave the following data:

0	to 155	Dry hole
155	to 161	Scant supply of mineral water
161	to 205	Dry hole
205	to 211	Light vein of mineral water
211	to 242	Dry hole
242	to 254	Scant supply of mineral water
254	to 266	Dry
266	to 283	Pure soft water (hardness, 100)
283	to 317	Dry hole
317	to 329	Scant supply of mineral water
329	to 346	Dry hole
346	to 384	Very light vein mineral water
384	to 405	Strong spouting vein (spouted 35 ft in air)
405	to 411	Dry hole
411	to 414	Strong spouting vein (spouted 35 ft in air)
414	to 423	Dry hole
423	to 426	Scant supply of mineral water
426	to 458	Dry hole
458	to 482	Strong vein of mineral water
482	to 485	Dry hole
485	to 498	Large supply of soft sweet water (hardness, 110)
498	to 510	Dry hole
510	to 540	Fair vein of mineral water
540	to 567	Dry hole
567	to 573	Fair supply of mineral water
573	to 585	Dry hole
585	to 595	Good vein
595	to 600	Dry hole
600	to 606	Fair supply of mineral water
606	to 622	Dry hole
622	to 629	Fair supply of mineral water
629	to 912	Dry hole
912	to 919	Fair vein of mineral water
919	to 928	Dry hole
928	to 935	Strong spouting vein of mineral water (spouted 40 ft high)
935	to 1,006	Dry hole

By separating the veins of mineral water by rubber seals and confining the large quantities of CO_2 gas that passed into the well with the veins of mineral water, three veins were found that contained enough gas to make the mineral water flow with a sputtering pulsating motion high into the air. Once started, the well would continue to flow until it was stopped by means of a water seal.

The water seal is a very curious phenomenon connected with the natural flowing wells that have been drilled and cased. If even in the strongest springs at Saratoga the tops of the casing be covered tightly so as to prevent the flow of water and gas, and if the tight cover be maintained for one or two minutes, the well will not resume its flow on removing the obstruction. If it be artificially started with a pump, it will flow as strongly as ever. The phenomenon is called the water seal, since the spring is, as it were, sealed off by water.

All the veins marked mineral water showed on analyses large quantities of soda, magnesia, lime, potassium, chlorine and CO_2 gas and small quantities of lithia, strontia, baryta, bromine, iodine, alumina, silica, radium and organic matters.

Of the most interest are the two veins of fresh water flowing into the well, one vein between 226 and 283 ft., the other between 485 and 498 ft. Mineral water was obtained above and below these veins. None of the rare elements found in the mineral water were found in these two veins. Where does this water come from?

The driller reported the drill passing through 62 ft. of drift; 713 ft. of dolomitic limestone; 231 ft. of Potsdam sandstone; total, 1006 ft.

*A previous article by the writer ("Engineering News," Jan. 18, 1917) explained some of the conditions surrounding the mineral wells, or "springs," at Saratoga. It may be stated here, by way of further explanation, that mineral waters at Saratoga are derived from an artesian horizon, but the water is not under sufficient pressure to cause it to flow at the surface; that these waters contain large quantities of carbon dioxide gas in solution, ranging from 1 to 2 volumes of gas at atmospheric pressure per volume of water, to 12 or 14 volumes of gas; that the quantity of gas which the water can hold in solution increases as the depth or pressure increases. At atmospheric pressure a volume of water will retain 1 volume of gas. Water derived from a depth and containing several volumes of gas, if brought to the surface, will release the gas that it contains in excess of 1 volume, as it approaches the surface. In flowing upward through the casing of a well the gas released acts as an air lift and practically all the flowing wells, or so-called springs, at Saratoga flow by virtue of the pressure of released gas and not by hydrostatic pressure.

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Steel Sheetpile Bulkhead Driving Affords New Experience to Designer

By Herbert D. Mendenhall*

SYNOPSIS—Some of the unexpected difficulties found in driving a sheetpile bulkhead wall of unique design at Jacksonville, Fla.

Some new thrills in the driving of steel sheetpiling developed during the course of construction of the reinforced-concrete and steel retaining bulkhead for the Commodores Point Terminal Co., at Jacksonville, Fla. This project was described in a general way by the writer in *Engineering News*, Oct. 21, 1915, p. 772. At that time all was well, for the designs were complete, they fitted perfectly the conditions as they were then known to be, and in the optimistic eye of the designer all sheetpiling interlocked perfectly, matched true to dimension from top to bottom, all wood guide piles centered exactly and did not get out in the way of the other materials to be placed—in fact, "all was joy in Mudville," for mighty Casey had not struck out!

Soon after that writing the game began, with a bellicose contractor heading one team and an obdurate engineer the other, with the old umpire Experience vainly trying to make a good showing for the onlooking fans, prominent among whom were a Board of Directors and a Criticizing Public.

It may be recalled that the design of the bulkhead embodied a unique combination of steel sheetpiling, I-beams and concrete. So far as casual investigation shows, a similar combination has never before been used in this class of work. It consists essentially of a row of interlocked steel sheetpiling of the Wemlinger heavy sections driven approximately 1 ft. into rock, stiffened every alternate pile or on 37-in. centers with 12-in. standard steel I-beams interlocked with the sheetpiling, and driven to a minimum depth of 34 ft. below the plane of mean low tide and in every instance to a minimum penetration of 3 ft. into rock. A diagram of the combination is herewith reproduced in Fig. 1, and a typical section made up of short lengths of the steel piling and I-beams interlocked and set up is shown in Fig. 2. The anchorage or tie-back system consists of a horizontal wale between successive I-beams tied back with rods and turnbuckles to a braced pile anchor system. The wales are built up of two standard 4-in. channels, each 2 ft. 11 in. long, bolted back to back with ¾x2½-in. machine bolts and separated by 1½-in. gas-pipe separators 1½ in. long on each bolt. At midpoint of this wale combination and on the centerline of the intermediate sheetpile a 1-in. rod, upset each end to 1⅜ in., ties the wall back to the anchor piles. Fig. 3 shows the wale combination in actual operation with the attendant irregularities. The point to this story is enveloped in the experiences encountered in driving the sheetpiling.

The piling interlock is fabricated from a ½x9-in pressed-steel clip riveted to the sheetpiling every 5 ft.

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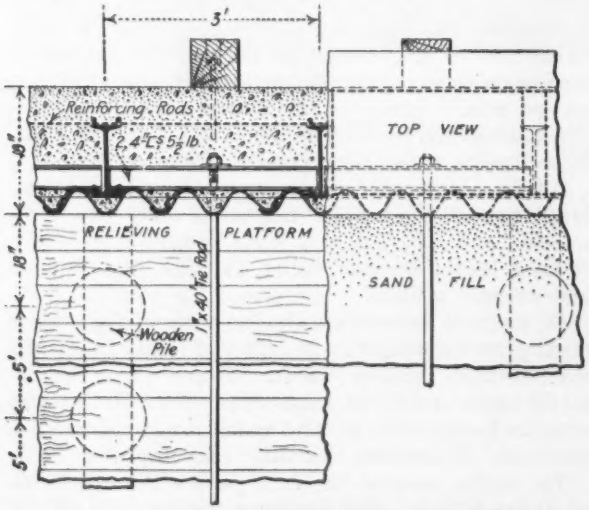


FIG. 1. TYPICAL HORIZONTAL CROSS-SECTION OF BULKHEAD

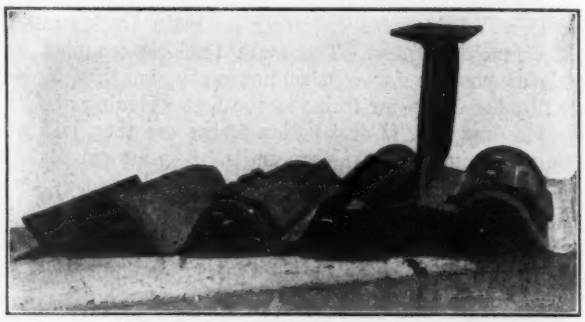


FIG. 2. MODEL SECTION OF STEEL BULKHEAD ASSEMBLED

in such a manner as to engage the edge of the preceding pile. The piling ranged in length from 24½ to 37 ft., except where spliced to get greater penetration, as will be described.

It was the roseate intention of the optimist—that is, the designing engineer—to drive the piles so that the clips of each succeeding one would conveniently and comfortably interlock over the edge of the one already driven, insuring a perfect joint along the entire length of all the piles. But, alas! "The best laid schemes o' mice an' men gang aft a-gley," and the steel company had put the clips on backward! Situation: Ten carloads of steel piling on hand and distributed, an ill-tempered contractor with full equipment just "r'aring" to start, a dredge waiting to begin pumping behind the bulkhead, and a frantic engineer responsible for the progress of the work tearing his hair to get things moving. Solution: Start operations anyway, reversing the order of things by driving the piling *into* the clips—dangerous, but expedient! Meantime a hot wire flashed to steel company to change sides with clips, and quick answer received that "on account of the war" it would be impossible to make any changes, or words of like import. Very well! By setting up and interlocking a long wall

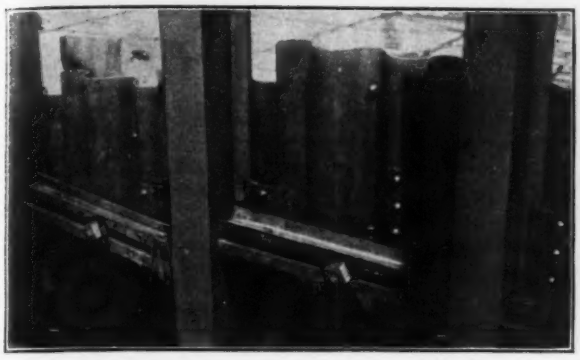


FIG. 3. ANCHOR WALES IN PLACE

of the piling before beginning to drive, everything should go safely enough. Method started and goes beautifully until driving begins, when discovery is made that the interlocking corrugations lap so far that the steam-hammer follower cannot engage the center of a pile without hitting the corner of the adjacent ones, and attempting to drive with the hammer near a corner deforms the piles too much. Hence, the only way left is to drive each pile separately before interlocking the next one.

This method did very well, and serenity once again pervaded the atmosphere. Resourceful engineer to think of and permit such a simple and successful expedient!

At 25 ft. from the point of beginning there commences a curve of 24-ft. radius, extending through 90°. According to the original scheme of driving, this curve could have been easily negotiated, as the direction of curvature would have loosened rather than tightened the piling in the clips. But for reasons already stated, the original procedure could not be followed, and so once again trouble stalked forth on the land! Fearing possible complications of the kind, the engineer left instructions at the close of the first day before starting on the curve to set up a number of piling ahead to test out the possibility of curvature before beginning to drive. Satisfied that this procedure would be carried out, said engineer sleeps peacefully that night, eats heartily next morning, only to be ruthlessly disturbed near end of breakfast by a wild telephone call from inspector stating that the contractor is refusing to carry out instructions to the letter because of a misunderstanding between the foreman and the inspector and that the piling is being driven regardless of consequences. By the time the engineer arrives on the job, six piles have been driven on the curve, the bottom of each pile extending farther out from the line of the bulkhead than its predecessor, due to lack of sufficient flexibility in the interlock to take the curve, a general mess resulting. The contractor, on being held up, contritely agrees to pull all wrongly driven piles and redrive them according to instructions. Very nice of contractor! But unfortunately, engineer knows that the driving was very hard and that rigging to pull the piles will cause a delay of several days—and an ominous dredge waiting to start! Accordingly, it is decided to drive the next pile out of the interlock and plumb to line, and to close the resulting gap at the toe by driving an additional pile behind.

Thence to the completion of the curve each alternate pile was driven out of the interlock in order to follow the sharp convexity. This procedure worked out with reasonable success, only two or three slight leaks resulting on the entire curve. Later, lengths of a lighter section of steel piling were driven inside the bulkhead opposite the cracks, successfully stopping the leaks.

After leaving the curve, driving proceeded nicely for about 300 ft. Then it became evident that there was a decided tendency for the tops of the piling to lean forward, necessitating the continuous pulling of them back with double blocks and tackle. This crawling ahead was caused doubtless by the slight deflection of the toe of the pile, either in or out, when it encountered the rock or even while being driven, and by the crowding of the piling back into the interlock—both of which actions would tend to shorten the line at the bottom of the piles, while the pulling of the piling against the guide wale would unfailingly keep the top line of the piling moving ahead to specified spacing. The continual pulling backward of the tops of the piles unavoidably caused a wavy appearance in the line of piling, and at a later date, when the wales and tie-back system were put on, necessitated the cutting of a number of the top clips in order to prevent a sharp kink from occurring at intervals. The shortening of line resulting from this procedure amounted to about 2 ft. in every 100 ft. of wall.

When the crowding forward had progressed to the point of becoming alarming, a joint conference of every-

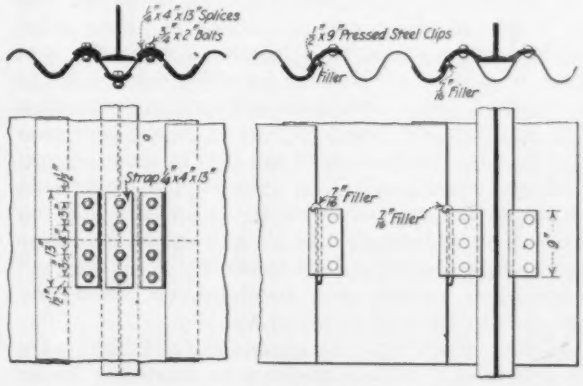


FIG. 4. SHEETPILING SPLICE AND CLIPS AND BOTTOM FILLERS

body who had an idea was called. It developed that in driving similar piling at a previous time, but with the interlocking clips located as they should have been, the tendency was always for the tops to drag back instead of crawl forward, necessitating a continuous pulling *forward* with the blocks and tackle. This was the consummation devoutly to be wished, as it would eliminate kinks and incidentally gain all slack in the interlocks. Accordingly, it was decided to change ends with the piling and drive them in the manner originally intended. This necessitated purchasing an oxyacetylene outfit and cutting a handling hole in the opposite end of each pile thereafter. To further keep the toe forced ahead as far as possible, a $\frac{7}{8}$-in. filler rod was inserted in each bottom clip, as shown in Fig. 4, thus gaining about ½ in. per pile. Still further gains were attempted by flattening out the forward edge of each pile for a distance of about 10 ft. from the bottom.

These various subterfuges resulted in reducing the loss per 100 ft. from about 24 in. to about 6 in. The total loss for the entire 5164 ft. of bulkhead was about 66 ft., or slightly over 1%.

As the level of the surface of the rock varied rapidly, necessitating different lengths of the sheetpiling, extra piling had to be inserted at frequent intervals to make up the loss in length of line and keep the proper lengths of piling located at proper points. Station distances were accurately marked on the guide wale, and the theoretical station number of each pile with its length was entered in an inspector's book. By means of this book and the marked station distances, the inspector could keep accurate account of the loss of length and insert the necessary extras when needed. And here developed another problem. Extra piling for fillers had to be ordered, but of necessity could not be delivered as needed. In fact, the accommodating steel company advised that it could not vary the order of shipping in any detail and would have to ship the extra pieces *last!*

But engineers, like their proverbial prototype, when crushed to earth will rise again; and once again a difficulty was overcome. Simply determine the length of piling that occurs most frequently and order all the extra pieces that length. Then put the fillers at the points where this length of piling is called for. Thus the shortage accumulated in one length only and was filled before the end came.

After meeting and solving the difficulty of making the feet keep up with the head, came the revelation that the lengths of piling were not coming in proper order, but in bunches of the same length. Result: Gaps, at times, of as much as 1000 ft., for which there would be no suitable lengths. Delays and most grievous complaints from contractors! Timid requests to angelic steel company that it, please, sir, send the steel in the order specified and agreed on! Curt response that they could not do it that way, as they had divided the order up into sections and proposed to fill each section indiscriminately as to continuity—but apparently "back end to." Inasmuch as we were only Americans, we should have been glad to get steel at all, at all.

As the piling began to accumulate and short gaps yet remained, it became necessary to substitute shorter or longer lengths for those called for at certain stations—trusting to luck that all would work out right in the end. As the rock borings to determine the profile of bottom had been made at 25-ft. intervals, naturally intermediate irregularities occurred frequently. By having the inspector watch the piling very closely, advantage could be taken of these irregularities and it was sometimes possible to put in shorter lengths of piling than those specified.

The character of the driving varied through wide ranges on the several parts of the work, with stiff mud for full depth at one point, quicksand for full depth at others, alternate strata of sand and clay at still others, and for one stretch of about 1500 ft. practically nothing was encountered before striking the rock. It was noticed that the tendency of the piling to crowd back into the clips at the bottom occurred mostly in the deep sand driving. Where nothing but rock was encountered and there was correspondingly very little driving, the piling even tended to lean backward at the top, making possible a pulling-ahead process and permitting a gain rather than a loss over theoretical spacing. But unfortunately, the hard driving predominated, and so an ultimate loss was sustained, as already mentioned.

In the beginning driving was attempted with a steam hammer only. A No. 1 Vulcan hammer with McDermott base and cast-steel driving cap was used. But as the sand became deeper and the friction resistance increased it became necessary to install a water jet to relieve the friction. After installing the jet, little more difficulty was experienced in getting the piling down.

Along one stretch of about 730 ft. of the bulkhead the rock bottom dipped to a depth that could not be reached with the I-beams. It was decided to gain the necessary foot stability by driving the sheetpiling deeper into a stratum of clay that lay from 4 to 12 ft. below the extreme depth of the originally designed piling.

At this juncture effort was made to get longer lengths of piling substituted for the ones ordered. The steel company could not consider such an accommodating act, not even at an advanced price for the substitute pieces. So it was decided to splice the short lengths. The type of splice used is shown in Fig. 4 and consisted essentially in bolting five 4x13x¼-in. straps in the corrugations as shown and hoping that they would be rigid enough to stand the necessary driving. As a matter of fact, they did drive very nicely on first appearance. The trouble did not develop until some time later, after the dredge had started pumping material in at that point, when it was found that the splices under the heavy driving had frequently offset just enough to let the clips on the succeeding pile pass behind the lower section and leave a continuous opening about 1 in. in width, from the bottom of the top splice-piece to the bottom of the wall. This defect permitted 1000 cu.yd. of material to pass through the bulkhead before it was discovered. These cracks were later stopped by driving extra piling behind the wall covering the cracks and in addition forcing calking material into the cracks from the outside. A diving apparatus was employed.

An ingenious method of maintaining a straight line against the intrusions of obstacles on the bottom was developed during the course of the driving. It was found that not infrequently the toe of the piling would encounter a peak of rock, a sunken log or other obstruction and would be deflected in or out from a straight line. This deflection would obviously shorten the bottom length of the line of piling and accentuate the dreaded crowding ahead of the tops. After several such obstructions had been encountered, it was discovered that the trouble could be overcome by ceasing to drive a pile the moment it showed signs of deflecting, pulling it back up until it stood plumb, and interlocking and driving several piles ahead of it and past the obstruction. This gave a strong guide for the partly driven pile, and it could then usually be driven on to grade without any shortening of the bottom line.

Advice for Such Work as This

1. In a long wall provide for some means of breaking the wall to permit straightening up of the piling. Tapered piling or "dutchmen" would answer the same purpose.

2. Provide in the specifications for setting up of the wall several piles ahead of the driving. Special followers may have to be provided to accomplish this.

3. Do not figure too closely the space a pile will cover, but make generous allowance.

4. Do not introduce too great refinement in ordering varying lengths of piling where the toe stratum varies in elevation. It only causes confusion in shipping and distributing, and may cause bad feeling toward the steel company.

5. Order the steel a sufficient time ahead of the need for it to forestall delays due to unexpected wars.

6. Provide an oxyacetylene torch and a diving helmet.

7. Do not get despondent, for others have had trouble too.

New Methods in Tunneling in Variable Soft Ground

By L. G. Warren*

SYNOPSIS—Radically new features in pneumatic tunneling were brought forth by the difficulties in the Milwaukee Shore Tunnel: Cutting hard clay and hardpan with air chisels; clay plastering of the timber sets and sheathing to hold the air; draining the face and bench by well points driven ahead. The operations are described in detail.

The Shore tunnel of the Linwood Ave. Intake System at Milwaukee encountered unusual difficulties due to variable soft ground and serious water conditions. The contractor was forced to devise original methods of dealing with the different conditions. Compressed air has been used throughout in all of the four headings except for a short starting period in the headings from Shaft 2. The pneumatic method alone, however, did not prove adequate to cope with the range of face conditions, from running sand to hardpan and shale, the total range sometimes appearing in a single face.

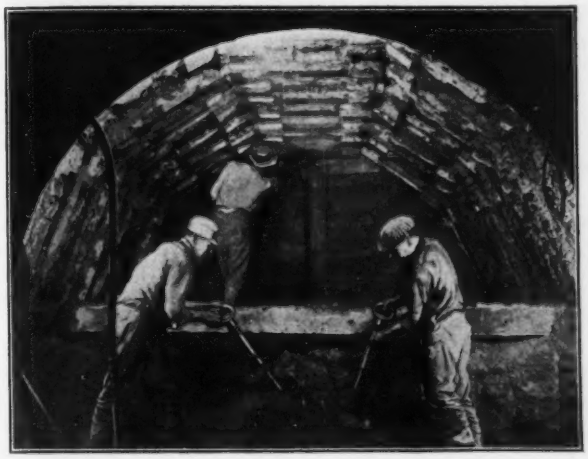


FIG. 1. CLAY-PLASTERED HEADING IN POROUS GROUND, MILWAUKEE SHORE TUNNEL

Soil above spring line is open sand and gravel, allowing escape of compressed air. Bench in stiff red clay is being excavated by air chisel. The entire surface of the timbering and breasting is being plastered with clay to hold the air; laborer in background is claying up

The tunnel is 9 ft. in diameter with 12-in. shell of plain concrete, making an excavation diameter of 11 ft. It will be 5644 ft. long. Operations are conducted from two shafts, of which the northerly is called No. 1 and the southerly No. 2. The success of the methods, both of construction and supervision, was assured on July 22, 1916, by the junction of headings between Shafts 1 and 2.

The tunnel is to serve as a connecting conduit between the Linwood Ave. intake or lake tunnel and the North Point pumping station. A sketch map of the intake system and a description of the work on the intake tunnel (a 12-ft. tunnel under the lake, 4000 ft. long) may be found in *Engineering News*, June 18, 1914, p. 1364. This tunnel is now being extended into the lake a distance of 2500 ft. In the future a 9-ft. concrete tunnel will be driven from the shore shaft of the lake tunnel directly west to a new pumping station about 7000 ft. west on Linwood Ave.

*Resident Engineer, Shore Tunnel, Milwaukee, Wis.

Conditions Encountered in the Tunneling

The advisability of employing the compressed-air method has been continuously substantiated as the drifts advanced. The drifts from Shaft 2 were started in normal air, but each met water-bearing gravel after progressing a little over 100 ft. Work from Shaft 2 started north and south on Sept. 13 and Sept. 17, 1915, respectively. Compressed air had to be applied in the early part of November. The headings from Shaft 1 started on Nov. 5. At this time, the necessity for the use of compressed air was already demonstrated, and, the shaft being 45 ft. off the line of the tunnel, a joint air lock for both headings was placed in the connecting drift.

The soil encountered has been water-bearing sand and gravel, deposits of a mixture of gravel with sand and lumps of shale and boulders, deposits of quicksand, decomposed shale, ledge shale, hardpan and boulders. The soil conditions have changed within a comparatively short distance from sedimentary to glacial deposits and vice versa. As high as nine distinctly different strata have been encountered in the same face within a vertical height of 11 ft. In one of the worst cases the face showed in order, from top to bottom, red clay, fine sand, washed gravel, coarse sand, decomposed shale, ledge shale, hardpan and boulders. The decomposed shale was met in a deposit 6 ft. thick later on in the mining; it was black, very compact, without stratification lines and was the result, probably, of a severe grinding action of natural forces, followed by enormous pressure. In every case, shale in ledge form lay beneath the decomposed shale.

The soil cover over the tunnel ranges from 19 to 98 ft. The tunnel passes partly under the lake beach and

FIG. 2. AIR BLOW ALONG LAKE SHORE FROM HEADING 300 FT. AWAY

North heading of shaft 1. Danger of blowout to lake set a limit on the air pressure that can be used in the tunnel

partly under the high bluff of Lake Park. The head of water has in general corresponded to lake level, being about 20 ft., but in several cases the head has been considerably above that due to the lake level.

A notable example occurred in the south drift from Shaft 2 at Station 9 + 84, following a collapse of the excavation roof, which resulted in an inrush of water amounting to about 200 gal. per min. At the time of the collapse the air pressure was 11 lb. It was then raised to 14½ lb., which held back the inflow for a time, but in a few hours proved inadequate. Successively 17, 18, 22, 23, 24 and finally 27 lb. pressure was applied with the same result. The tunnel invert was 27½ ft. below lake, equal to about 12 lb. hydrostatic pressure. It was in this experience that the use of well points for draining the face was suggested and tried, with success, as will be described later on.

A limit to the amount of air pressure that could be used lay in the nearness of the lake shore, particularly

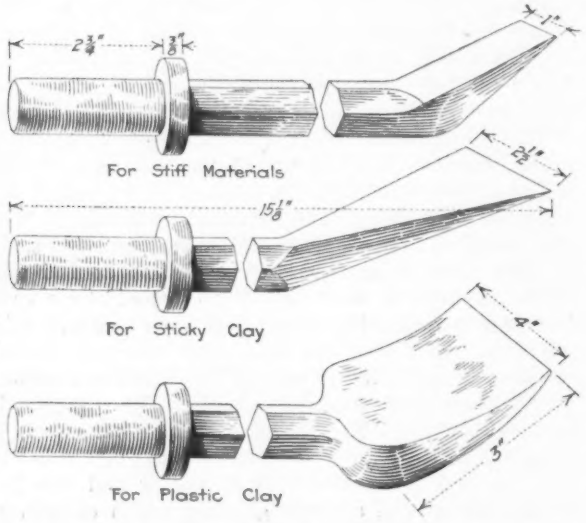


FIG. 3. AIR-CHISEL BITS FOR HARDPAN AND CLAY

The narrow chisel is successful in hardpan but failed in sticky clay. The wide bits handle sticky and plastic clay effectively. The hammer used has 1½-in. bore and 3½-in. stroke

in case of the north heading from Shaft 2. Great care has been used in this heading to have the air pressure exceed only slightly the hydrostatic lake-level pressure. Distinct blowing through of air was observed in the water close along the shore line on many occasions (see Fig. 2). It was felt that the danger of blowing a large opening through the sand to the lake existed, in case of any material rise in air pressure in the heading.

Slow Progress in Hardpan; Pneumatic Chisels Prove the Solution

Ordinary pick-and-shovel mining was started in all headings. The material that gave most trouble in the early stages was hardpan, with pockets of gravel, and stiff, stony red clay. On account of the slow progress with hand picks, blasting was tried, using 40% dynamite. This materially increased the speed of mining per shift, but any gain was offset by the delays caused by several roof falls, due to the blasting. After less than 300 ft. progress in one heading and after only 29 lin.ft. in another heading, blasting was discontinued. The contractor's superintendent, Daniel O'Connor, made a trial of pneumatic hammers, and almost from the start they demonstrated themselves as the successful solution of the difficulty.

The first bits tried were 1-in. diameter steel with 1-in. chisel-shaped cutting ends. The hammers were of small size (Ingersoll-Rand chipping or scaling hammers). Increased speed of mining and decreased danger of roof falls resulted, and the exhaust from the tools also aided ventilation. After nearly nine months' experience with this method of excavation the opinion on the work is that the pneumatic hammers have solved the problem of mining in stiff soil and also dealing with ground in which the stratification changes rapidly.

The hammer is used to scale off pieces of the soil, being held almost parallel to the face. The bit in most cases is slightly bent forward at the point to facilitate the flaking-off process. Several different forms of bit were evolved as the work went on. Referring to the drawing, Fig. 3, the narrow chisel was found to operate well in hardpan and in gravelly clay. The wide bits were used for mining in sticky clay and in plastic clay, after the narrow chisel proved itself a failure. The wide bit was satisfactory for every operation in the sticky clay and would remove in one bite from one to two shovelfuls of soil.

The progress made with the hammers may be judged by the average figure of 3.70 lin.ft. per 10-hr. shift, with the pneumatic hammers, against 2.84 lin.ft. in the same time with hand pick work. The excavation quantities corresponding to these two figures are 14.17 and 11.84 cu.yd. This was in semistable soil. The average progress in stiff blue clay, using the pneumatic hammers, was 6 lin.ft. in 10 hr. (June, 1916).

Box-Drift Advance with Clay-Plastered Surface

Open gravel strata and water-bearing strata presented very serious problems, which were met finally by the adoption of box-drift advance with full clay plastering of all surfaces, both of soil and timber. The development may be sketched by detail reference to the north heading from Shaft 2.

Originally, work was carried on in this heading without compressed air. About a month after beginning the excavation, the first face collapse occurred, at Sta. 1 + 16.5; it brought in a mass of sand, gravel and boulders and 300 gal. of water per min. From that time until successful junction with the south heading of Shaft 1 the work continued to be an unending battle to drive ahead. This is best shown by the fact that 780 ft. of advance was made in eight months, or less than 100 ft. per month. All of this was through running sand and gravel deposits in at least a part of the face.

After the first collapse, compressed-air equipment having been installed, the heading was placed under air pressure on Nov. 5. Low pressure on Nov. 17 and 18, the air dropping to 9 lb., brought more face collapses and increase of water, the inflow now amounting to about 600 gal. per min. The water was driven back by increasing the air pressure to 13 lb. On Nov. 29, at Sta. 1 + 54, after various attempts to grout the collapsed heading, work with a different method of advance started. A narrow top heading or box drift, 5 ft. wide at the top, 8 ft. 3 in. wide at the bottom and 6 ft. 6 in. high, was started. This box drift employed three-segment timber sets of 20-in. longitudinal spacing, and such a sequence of operations that only a very small area of ground was

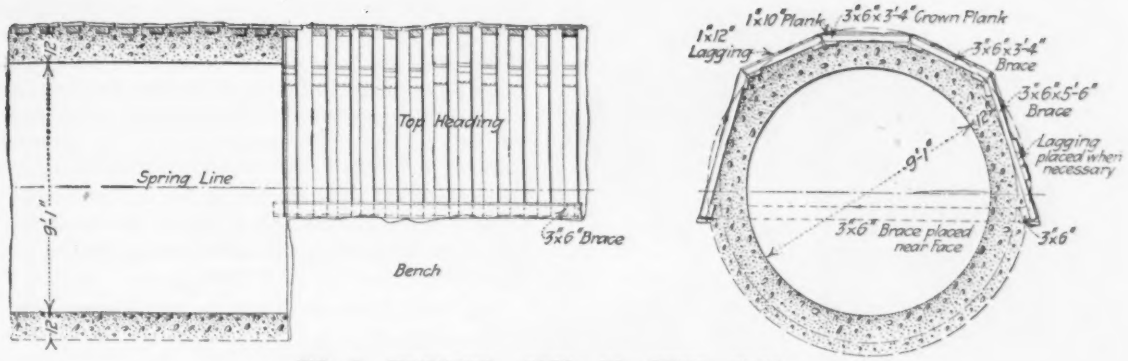


FIG. 4 TIMBERING USED IN STIFF CLAY

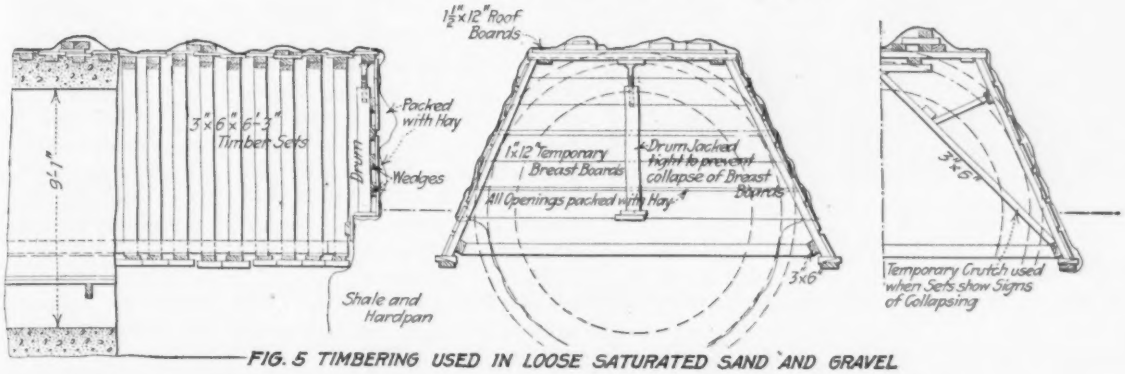


FIG. 5 TIMBERING USED IN LOOSE SATURATED SAND AND GRAVEL

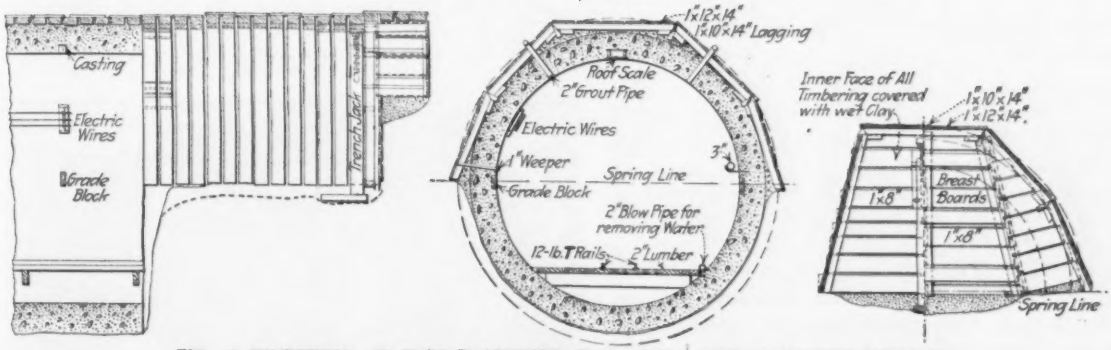


FIG. 6 TIMBERING OF CLAY-PLASTERED BOX DRIFT, USED IN WORST GROUND

FIGS. 4 TO 6. DIFFERENT ARRANGEMENTS OF ARCH TIMBERING USED IN THE SHORE TUNNEL

exposed at any one time, at all other times both exposed soil face and timber being covered tight with a plastering of soft clay. Fig. 6 sketches a heading timbered under this system, and may be compared with the normal timbering of Figs. 4 and 5.

The advance of the box drift is made by 20-in. bites until a 10-ft. advance is obtained. The first step in the advance is to remove the top breastboard and then take away the soil for a horizontal depth of 20 in. and a vertical depth of 10 in. Roof boards 1 in. thick, 10 in. wide and 20 in. long, with long edge parallel to the tunnel axis, the top surface covered with soft clay, are placed in the small area of roof exposed. Then two 3x6-in. transverse crown timbers 5½ ft. long are laid against the roof boards. These timbers are held temporarily by a 3x8-in. cantilever crown bar 6 ft. long supported by a trench jack until the side pieces of the three-piece set can be installed. The 10-in. face of the excavation for the new roof boards is quickly covered by 1x10-in. breastboards, also clay plastered, and braced against the trench jack. Then the entire breast is brought to the new face by successive 10-in. vertical depths of advance, placing the new breastboards in 10-in. sections. As the excavation of this 20-in. bite progresses and the sides of the box drift are exposed, these are covered with 1x10x20-in. boards clay-plastered on the outer surface. This side sheeting is held by the legs of the three-piece set when placed. The crown timber of the three-piece set is permanent, as it becomes the crown timber of the final five-piece set of the full-sized excavation.

When the box drift was first started, a heavy escape of compressed air passed through roof, breast and sides, and it was found necessary to cover all surfaces with clay, thoroughly wet. This use of clay has been continued. Fig. 1 shows a heading where the application of clay is just started.

The clay plastering has been made an essential feature of the excavation in loose ground. Constant vigilance is required to prevent blows, and generally one man is detailed to the sole duty of going over the clay plastering

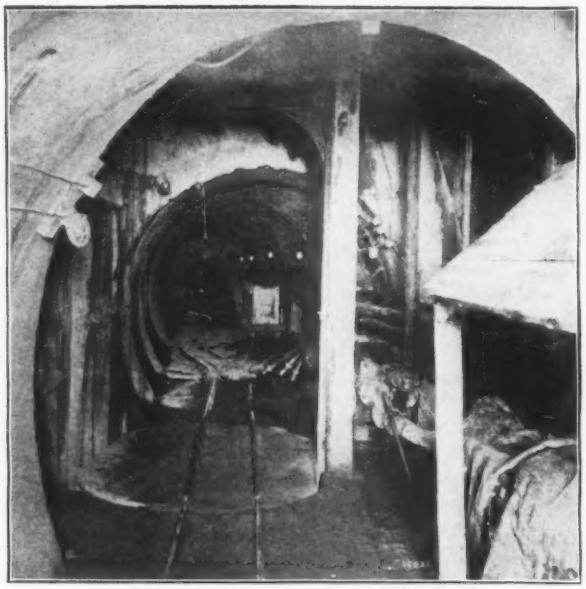


FIG. 7. HEADING FROM FOOT OF SHAFT 2, LOOKING TOWARD AIRLOCK

that covers sheeting and timbers, and closing cracks and holes as fast as they appear under the drying-out effect of the air.

Full-section excavation is made as soon as the box heading has reached a 10-ft. advance. The widening out is done with precisely the same care to expose only a very small area as in the advance of the heading. The widening is done in two stages, roof to spring line being done first with completion of the permanent five-piece timber sets, and excavation of the lower half of the section then following.

The condition of affairs when the box drift was first employed was that the face consisted of fine brown sand above the spring line and in the roof, and stiff red clay in the lower half. The clay, however, gradually disappeared as the heading advanced, and ultimately dropped to near the bottom, with gravel below it. Under these circumstances, longitudinal 1x10-in. planks had to be installed along the entire lower half of the excavation, whereas elsewhere sheeting was used only above spring line (or above the footing plates of the sets where these were carried down lower).

The clay-plastered box drift was continued in the north heading of Shaft 2 for about 240 ft. It was also used successfully in excavating through a full deposit of water-bearing sand from Sta. 9 + 70 to 10 + 44 in the south heading of Shaft 1. The average progress of the full-section excavation with the box-drift method has been 1.27 ft. in the 10-hr. shift.

The advantages of the system are that only a small area of ground is exposed at any one time, which lessens the air loss and danger of a run of soft soil, and the fact that the very short advances at the face give almost sure control of the soil. The almost perfect control of air loss by the clay plastering has proved an especially valuable feature of the method.

Successful drainage of wet face and wet benches has been accomplished by pumping from well points driven into the face or bench. This expedient was suggested by George W. Jackson, member of the contracting firm, in the case of a bad collapse in the south heading from Shaft 2, Sta. 9 + 84, when water was coming in at the rate of 200 gal. per min. and the air pressure, even though raised from 11 to 27 lb. per sq.in., was unable to control it. As the hydrostatic head corresponding to lake level was only 12 lb., it was unsafe to raise the pressure further, and the water had to be brought under control before face excavation could continue. Well points were driven 18 in. into the face about 3 ft. below the excavation roof. The material was fine sand above springing line and soft clay below.

Draining Face by Well Points Driven Ahead

Fig. 9 sketches the arrangement of the well points. They were all connected by hose to a valved manifold placed upon the 3-in. blowout line; a ¼-in. hole in the blow pipe for admitting air at tunnel pressure gave an ejector effect to supplement the inward pressure at the well points. On opening the valves, the pressure of the air acted through the mesh of the well points and the blowout line, and the well points then were the natural place of escape for the compressed air, which carried the water with it. The result was very successful. Four 1¼-in. well points easily controlled the inflow from the face and dried the roof.

The air pressure in the drift was 27 lb. at the time the well points were started. The pressure was gradually reduced to 13 lb., the well points continuing to operate with excellent results.

Later, the well-point method was used to drain wet benches in fine sand, with equal success. It is the opinion of those who have seen the well points in service in this

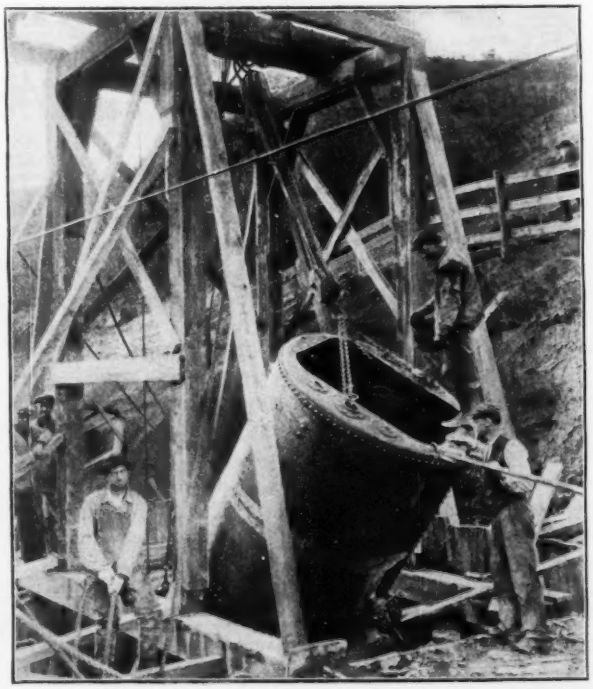


FIG. 8. LOWERING STEEL AIRLOCK DOWN SHAFT 2

heading that an important advance in tunneling has been made by the employment of this method. Their use gives control over a wet face in soft soil that cannot be controlled by the aid of compressed air alone at moderate pressure.

After a collapse of timbering in one of the headings, due to undermining of a footing plate, the 8-ft. open length of heading in soil of gravel and boulders caved in. To recover this heading by direct mining in a disturbed soil would have been a very dangerous procedure.

Grouting a Collapsed Heading

A 9-in. concrete bulkhead backed by a 3-in. timber bulkhead, was built immediately as close to the point of collapse as possible, and the heading was grouted through a pipe passing through the two bulkheads. Grout was pumped in to the point of refusal, and the heading was then abandoned for two weeks to allow the grout to set thoroughly. When it was reopened the solid grout and cemented gravel and boulders were mined through by pneumatic hammers without any difficulty or mishap. Timbering was not required, as the grout formed a solid mass that was completely self-supporting over the arched excavation.

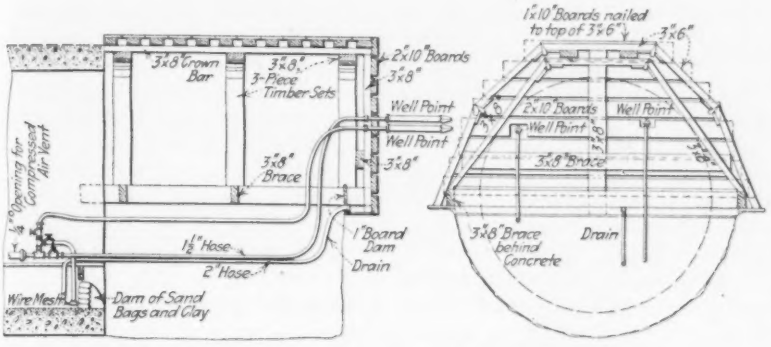


FIG. 9. HEADING FACE DRAINED BY WELL POINTS

Different Kinds of Timbering

In all headings the excavation has been carried out in top-heading and bench arrangement. The top heading usually extended down about a foot below spring line, making the bench about 5 ft. high. The nature of the ground and the resulting method of timbering, however, affected the height of bench considerably. In the stiff clay the arch was held by timber sets founded on foot blocks, usually at or 12 in. below springing line (Fig. 4). These were five-piece segmental sets of 3x6-in. maple, consisting of a crown timber 42 in. long and two 48-in. side segments on each side, all framed with beveled joints. The sets were spaced to suit conditions, from tight setting to 5-ft. spacing. This type of timbering would not hold heavy earth pressures, yet it served to prevent movement of the roof soil and also held any small chunks or slabs of loosened material, thereby lessening the danger to the men.

In softer soil, as sand and gravel, the timbering usually consisted of three-piece sets of 3x6 maple (Fig. 5), with a 6½-ft. crown timber and 7-ft. legs resting on plates or footing blocks set well below springing-line level and giving in effect an almost flat floor, which was secure and stable except in a very few cases where invert planking had to be put in. These sets were placed solid, edge to edge.

In those soils where the box-drift method of excavation was resorted to, the standard three-piece set was not adaptable, as it would have required double roof timbering. A modified five-piece set was used here, of such arrangement that the crown timber of the box drift served also as crown timber of the permanent five-piece set, making the bench about 5 ft. high ordinarily. The excavation ranged from 2.28 cu.yd. to 2.68 yd. per lin.ft. in the heading and 1.40 to 1.65 cu.yd. per lin.ft. in the bench.

An advance of 9 ft. before concreting was first tried. This was gradually lengthened, however, with experience and practice to a maximum of 15 lin.ft. of advance wherever the stability of the excavation roof permitted. In all cases concreting followed, section by section, immediately behind the excavation, each section being concreted close up to the face. The contractors paid close attention to limiting excavation to the neat line, but the nature of the soil and the rapidity of its changes prevented entire success in this effort. There has been surplus excavation throughout, the average amounting to 0.20 cu.yd. per lin.ft. outside the line of the 12-in. shell. This amount was measured by the concrete put in for the lining. Part of this is accounted for by the considerable departure of the invert from the theoretical semicircle where the timber sets are carried down well below springing level, as shown in the drawing in Fig. 5.

Engineers and Contractors

The whole construction is being conducted under the charge of George F. Staal, City Engineer, the writer supervising the construction operations. The contractor is the O'Brien & Jackson Construction Co., of Chicago; Daniel O'Connor is superintendent. The forces maintained by the city on the contract comprise five construction inspectors, two engineering inspectors, one transitman and one draftsman, besides the resident engineer.

⁂

Local Engineering Society Makes Influence Felt—"Some progress has been made in the direction of taking a more active part in the public affairs of the city and state. This is one of the principal objects of the Oregon Society of Engineers, as specifically set forth in its constitution—namely, to organize engineering opinion in matters of public interest. One of the great advantages that a local engineering society has, over the local branch of a national society is the freedom which it has to enter more closely into the life of the community in which it exists. The national society is bound to a certain extent not to voice its sentiments on questions of public interest without first consulting the parent organization. This greatly handicaps it in such action, owing to the time required to get permission to act and the probability that on certain questions such permission will not be granted. The Oregon Society of Engineers, however, is entirely free to take any action it may see fit in any given case, and only needs to exercise caution not to be rushed too freely into expressing its convictions in a public manner. Such work as the society has done in this connection has been largely in the way of committee work directed by the executive board, and may not have been fully noted by many of the members. One of the earliest endeavors in this line was made nearly three years ago, when the society put forward for the nomination of city commissioner a well-known engineer and materially assisted in placing him in office and at the head of the department of public works. The result of this action has, I believe, been beneficial to the city and creditable to the profession, and the society has no need to regret its action in the matter."—Williams S. Turner, in a presidential address to Oregon Society of Engineers.

Activated-Sludge Plants at Houston, Texas

By C. L. Williford*

SYNOPSIS—Two activated-sludge plants with a combined capacity of 19,000,000 gal. a day, with continuous-flow aëration tanks, vertical-flow settling tanks, sludge-reaëration tank, rotary positive-pressure blowers and pitot-tube air meters.

The construction of activated-sludge plants with a total capacity of 19,000,000 gal. per day is now well under way at Houston, and it is expected that the plants will be ready for operation by April 1, 1917. Though a comparatively new method of sewage treatment, it was shown by thorough tests under working conditions to have considerable advantages over older methods and was adopted as being best suited to all the requirements, local conditions and natural advantages. The prevailing mildness of temperature, the condition of the sewage after passing through an extended sewer system and being pumped, the small area required, the absence of objectionable odors and the large removal of suspended matter were some of the factors considered in the selection of this method.

Preliminary tests were conducted over a period of one year, the last four months being directed solely to the activated-sludge method. A description of these tests and their results are amply set forth in a recent printed report by the City Engineer, E. E. Sands, under whose direction they were made.

The present population within contributing distance of the plants is estimated at 140,000, about half of which is now connected to the sewers. The sewers are built upon the separate system. All the sewage is passed through screens having 1-in. openings, chiefly for the purpose of protecting the pumps, and about two-thirds of the total is passed through a grit chamber. In order to utilize a number of miles of sewers constructed some time previously in pursuance of another plan of disposal, it was necessary to build two plants, on opposite sides of the city. It was desired to provide for a total population of 225,000 connected to the sewers. Gagings placed the present average flow at 85 gal. per capita per day for the population connected to the sewers, and this was used in estimating the quantity to be treated.

The plants have been designed in units for convenience and flexibility of operation. The north-side plant consists of four units, and the south-side plant of two units. Each unit is capable of treating the sewage of 37,100 persons, giving an average flow of 2,190 gal. per min., and

*Assistant Engineer, City of Houston, Tex.

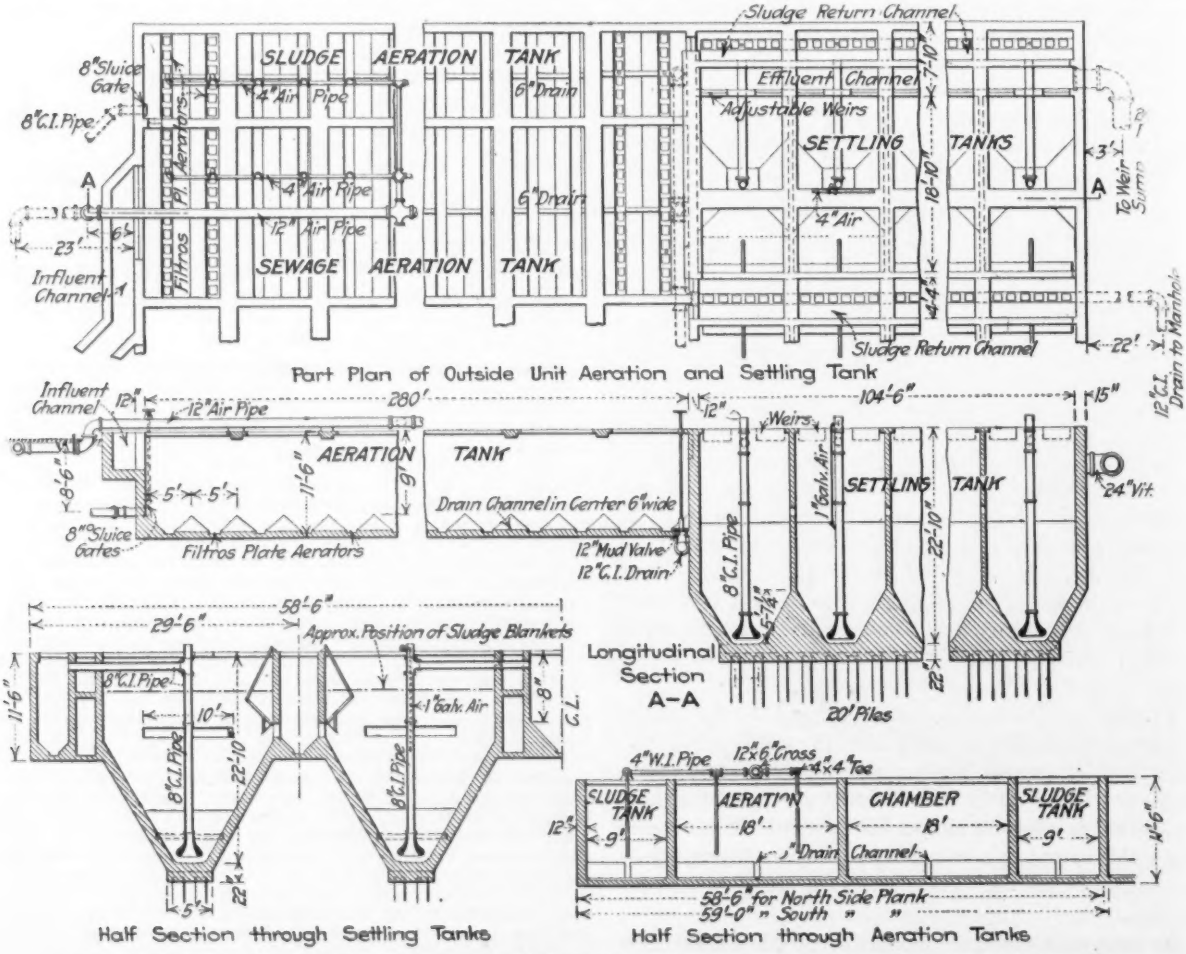


FIG. 1. GENERAL PLAN AND SECTIONS OF PORTION OF ACTIVATED-SLUDGE UNIT, HOUSTON, TEX.

a maximum flow of 2680 gal. per min. per unit. Each unit consists of a rectangular continuous-flow aëration tank, a battery of 10 vertical-flow settling tanks and a sludge reaëration tank, the whole supplied with means for distribution of air under a pressure of 5¼ lb. per sq.in. (See Fig. 1 for plan and sections of a part of one unit.)

Each aëration tank is 18x280 ft. in plan, with a net depth over aërators of 9 ft. 9 in. The net volume of the

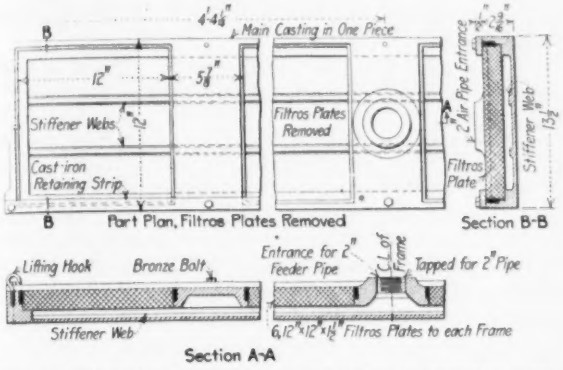


FIG. 2. FILTROS PLATES AND FRAMES, HOUSTON, TEX.

tank when full is 340,000 gal. The ratio of tank surface to tank volume is 1 sq.ft. to 67.4 gal. Grade 5-1 filtros plates, 12x12x1½ in. in size, are set in the bottom of the tank in cast-iron frames (see Fig. 2). The frames are placed in rows across the bottom of the tank, spaced 5 ft. c. to c., for the full length. There are 112 frames to each tank, each frame holding six aërator plates, giving a total of 672 aërators to each tank. The ratio of aërator surface to tank surface, then, is 1 to 7½. The tanks will be supplied with 0.26 cu.ft. of free air per minute per square foot of tank surface. The average detention period in the aëration tanks will be 1 hr. 50 min., and the minimum 1½ hr. Allowing 30% of the volume of the tank to be occupied by sludge, the average unit volume of free air supplied will be 0.33 cu.ft. per gal. of sewage per hour treated.

After aëration the mixture of sewage and sludge will flow directly to the settling tanks through a channel 4⅓ ft. wide, 9¾ ft. deep and 104 ft. long. This channel has aërators placed at intervals in the bottom to prevent settling of sludge. The 10 settling tanks are placed in a row beside the channel, and large slots with adjustable gates connect the channel with the tanks. The settling tanks are 10x18 ft. 10 in. in plan and 21 ft. 10 in. from water surface to bottom. They have conical bottoms and are supplied with vertical 8-in. pipes in the center, fitted to act as air lifts to remove the settled sludge. The volume of each tank is 22,000 gal. They are designed to act on the vertical-flow principle, the path of the sewage being across and upward to the effluent weirs on the opposite side from the distributing channel, while the direction of motion of the settling sludge is downward. It is proposed to maintain a blanket of sludge somewhat below the surface to act as a strainer to remove fine particles of sludge in suspension. This necessitates a very low velocity of flow in the tanks, since the sludge is very light and extremely sensitive to impelling currents. It is estimated that this velocity will be about 2.7 ft. per min. It cannot be said at this time just how successful this plan will prove, and it will be an interesting feature of operation to be observed. The design is such, however, that a simpler method of sedimentation can be resorted to if necessary. The effluent passes from the settling tanks to a collecting channel and thence to the river without further treatment.

The settled sludge is removed from the settling tanks by the air lifts and flows into a sludge-collecting channel that leads into the end of the reaëration tank. This tank is 9x280 ft. in plan, of the same depth as the aëration tank and, except for width, is identical with it in construction. The concentrated sludge is here aërated for an average period of 3 hr. and reënters the aëration tank at the influent end to become mixed with the sewage again. Excess sludge will be pumped from the end of this tank for further treatment. The volume of air supplied to the sludge in reaëration is 0.23 cu.ft. of free air per gallon per hour aërated. Under normal conditions it is believed that the rate of flow can be increased 25% above that for which the plants were designed, without increasing the volume of air supplied.

All tanks and channels are built as monolithic structures of reinforced concrete. Walls have been designed for full earth pressure outside and full water pressure inside. All concrete will be waterproofed with integral waterproofing. Sloped walls in the settling tanks will receive special trowel finish to prevent accumulation of sludge. Great care has been taken to avoid dead spaces and corners where sludge could accumulate and become septic. Short-circuiting and inadequate aëration of any part of the sewage are thought to be entirely avoided. There are no sludge channels or pipes without means of thorough agitation.

Wrought-iron pipes for air distribution, ranging in size from 12 to 4 in. diameter, are carried on small slabs across the top of the tanks. Vertical 2-in. galvanized pipes connect the distributing system with the aërator frames. All bolts and screws in contact with sewage are made of bronze. Valves are placed at advantageous points throughout the system to facilitate control. The volume of air supplied will be measured by meters (Fig. 3) fitted with pitot tubes and a differential gage, placed between the blowers and the tanks. Air will be supplied by rotary positive-pressure blowers made by the B. F. Sturtevant Co. Each blower has a capacity of 3750 cu.ft. per min. at a pressure of 5¼ lb. per sq.in. Three blowers will be placed at the north-side plant and two at the south-side plant. Four of the blowers are driven by 150-hp. 3-phase

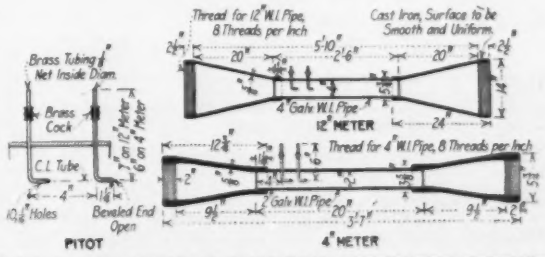

Thread for 12" W.I. Pipe, 8 Threads per Inch
Cast Iron, Surface to be Smooth and Uniform.
Brass Tubing, Net Inside Diam.
Brass Cock
C.L. Tube
4 Holes
Beveled End Open
4" Galv. W.I. Pipe
12" METER
Thread for 4" W.I. Pipe, 8 Threads per Inch
2" Galv. W.I. Pipe
PITOT
4" METER

FIG. 3. AIR METERS, HOUSTON ACTIVATED-SLUDGE PLANT

60-cycle 2200-volt motors made by the General Electric Co. At each plant there will be one constant-speed motor and one multiple-speed motor. At the north-side plant one blower will be driven by a 150-hp. twin Standard fuel-oil engine of the Diesel type. This engine is being installed for the purpose of reducing the power consumption at the plant at the time of peak load at the generating station, by which arrangement an advantageous power

rate was secured. Power will be furnished by the Houston Lighting and Power Co. Air will be filtered through muslin screens before entering the blowers.

Brick buildings of substantial design and pleasing appearance, equipped with traveling cranes, are being erected as power houses at the plants. A frame office and laboratory building is provided at the north-side plant, and a small office and storeroom at the south-side plant. All laboratory work will be conducted at the north-side plant, and it is intended to operate the plants under capable supervision in conjunction with thorough chemical and biological analyses.

Plans for the final disposal of sludge are being held in abeyance at this time, awaiting the development of better methods. A large amount of work is being done elsewhere along this line, and it seems probable that an efficient and acceptable method will be worked out in the course of the next few months. It appears probable at this time that final settling tanks and mechanical presses and driers will be the method used. A centrifugal pump of 500 gal. per min. capacity is provided at each plant to deliver the excess sludge to the dewatering apparatus. Three fertilizer plants are located in the city, and it is expected that all the available sludge will be consumed locally. It is impossible to give at this time even an approximate estimate of the quantity of sludge to be expected since this is a rather variable item and one not easily calculated.

To avoid the use of force mains from pumping stations to the plants a large amount of excavation was necessary for the construction of the plants. At the south-side plant 20,000 cu.yd. of material was removed, mostly loam and stiff clay. At the north-side plant 90,000 cu.yd. was removed, consisting of sand, clay and marl. This excavation was done at a unit price of 27½c. per cu.yd., the material being removed from the site. The top of the tanks at the south-side plant is 6½ ft. below the natural ground surface. The north-side plant is situated on sloping ground, and the average depth from natural ground surface to the top of the tanks is approximatly 12 ft. The excavated areas are sufficiently large to provide ample room around the tanks. Banks are cut on 1½ to 1 slope and will be sodded to prevent erosion. The excavated area at the north-side plant is 3.2 acres, and at the south-side plant 1.3 acres.

The following construction costs taken from contract prices are here given:

	North Plant*	South Plant†
Excavation	$24,750	$5,500
Contract price, plant complete, except machinery	186,550	88,050
Machinery and equipment (purchased by the city)	22,184	9,760
Estimated cost of sludge-handling equipment	20,000	10,000
Total	$253,484	$113,310
Total cost both plants		$366,794
Cost per million gallons per day capacity		19,305
Cost per 1,000 contributing population		1,630

* North-side plant, 12,615,000 gal. capacity per day. † South-side plant, 6,310,000 gal. per day.

When conditions become such that the plants are operated at full capacity, it is estimated that the cost of treatment will be $9.15 per million gallons per day, including interest and depreciation. It is evident that both construction and operating costs would have been somewhat reduced if it had been possible to build one central plant instead of two separate plants.

The layout of the plants is compact, and the design is such that additional units can be provided when needed, without alterations to the present structures. The plants require an almost inappreciable hydrostatic head for their operation. The head to create circulation of the sludge is maintained by the air lifts in the settling tanks.

Filtros plates for distribution of air are not considered altogether satisfactory in some respects, but being the best method available at this time, they will be installed and given a trial. It may be worthy of mention that a plate used for four months under adverse conditions in an experimental tank was recently broken and showed a clean fracture with only a very thin line of deposit on the upper side.

The degree of purity expected from the effluent of these plants is indicated in a general way by the following:

Oxygen consumed	88 to 90% removed
Suspended matter	95 to 98% removed
Nitric nitrogen present	7 to 10 p.p.m.
Bacteria per c.c.	95 to 99% removed
Relative stability number	100 (Phelps test)

In connection with this work, the Willow St. pumping station is being rebuilt and equipped with new machinery, and one new pumping station is being constructed. In addition to this, several miles of 36- and 42-in. gravity mains have been constructed from pumping stations to disposal plants. A later article will describe these.

The contract work is being executed at the north-side plant by Horton & Horton, and at the south-side plant by Jerome Cochran, Jr. The general features of design are the work of Mr. Sands. The writer is in charge of design and construction of sanitary sewers and disposal works.

Recommended Practice in Concrete Road and Pavement Construction*

By H. Eltinge Breed†

The following observations are based upon such knowledge as may be gained by inspection of concrete pavements in various parts of the country, and, more validly, on the actual construction in New York State of 201 mi. of second-class concrete pavement, 1:2½:5 mix, a type which we have ceased using; and upon the actual construction of 364 mi. of concrete pavement, 1:1½:3 mix, built in the last four seasons. There still remain 127 mi. of this type of construction under contract.

General Pointers

Maximum Grades—Our original practice was not to exceed 5%, but today we are building pavements on grades as steep as 8%, under certain conditions. Grade seems to be limited only by the ability of the wet concrete to run during the process of construction, by the character of the mix and the kind of traffic.

Minimum Widths—Most of the roads we have been building in New York State are 16 ft. in width. It would be far better, however, and ultimately more economical, if we had sufficient funds to build them 18 ft. wide. For two lines of traffic on a concrete road 18 ft. should be the minimum width; for three lines, 24 ft.

Square-Cornered Edges—The edge of the concrete slab next to the shoulder should be vertical and square cornered. Then if it becomes necessary to reinforce the shoulder with road metal a good joint can be made; and,

*From a paper, "Best Practice in Concrete Road Construction," read Feb. 7, at Seventh American Good Roads Congress, Boston, Mass.

†First Deputy Commissioner, New York State Highway Department.

more important still, if additional widening is required, it can be accomplished with a longitudinal joint of minimum size. We have very satisfactorily widened some miles of square-edged concrete roads.

Essentials of a Good Subgrade

1. It must have uniform bearing power. If an old roadbed is to be used it must be scarified, reshaped and rerolled for the entire width of the pavement, removing all large stone to a depth of 6 in.

2. It must be dry. Ditches should be low enough to take away the water from under the pavement. With unstable soil good results can be secured by providing subdrains and spreading a layer of gravel—preferably run-of-bank gravel—over the subgrade to increase its stability. Material used for this purpose must be impervious; if it is porous it will act during wet periods as a reservoir, which, under conditions of frost will break the pavement proper.

3. The pavement should be reinforced: (a) under very bad, i.e., unequal soil conditions; (b) wherever the supporting power of the subgrade changes; as from rock to earth, or passing over a trench. Our experience indicates that the expense of reinforcement is not justified in gravelly or sandy soils where good natural drainage prevails.

Proportioning the Mixture

With our requirements for materials we have found that the proportion of 1 : 1½ : 3 gives the greatest density. Our specifications provide that the concrete shall be mixed in the proportion of one volume of cement to 4½ volumes of sand and broken stone or gravel, and the proportions of fine and coarse aggregate are varied slightly as a result of field tests for void to give greatest density.

Stone—The coarse aggregate should consist of a well mixed product of clean stone, No. 1 (retained on ⅜-in. and passing ⅝-in. circular opening), No. 2 (⅝ to 1½-in.) and No. 3 (1½ to 2¾-in.). Not more than 25% of the total should be No. 1. We allow as our maximum size stone that will pass a 2¾-in. ring, while most specifications permit only 1½-in. stone as a maximum. Our reason for the increase in size is that better results are obtained at less cost. We save 15% in crushing costs by this use of larger stone.

Sand—Sand should be such that 100% passes the ¼-in. screen; not more than 20% a No. 50 sieve and not more than 6% a No. 100 sieve. However, where more than 20% of the sand passes a No. 50 sieve, where it is well graded to give a low percentage of voids, and where it conforms to all other requisites, special permission for its use may be given. It should not contain more than 5% silt or loam.

Importance of Field Tests

Our work has shown that if we are to omit any of the tests, we might better take a chance with the cement, for of the last 455,000 bbl. used only 1.4% failed to conform to the test of the American Society for Testing Materials. There has been a far greater proportion of both sand and stone rejected.

The principal tests which can be made in the field accurately enough for all practical purposes are:

1. Gradation tests for sand. Our field men are furnished with sand testers which have the ¼ in., the No. 20 and the No. 50 sieves. By using these they can be assured of getting a uniform product from the bank, for they would at once detect any change for the worse in the character of the material and would reject it. Each engineer is supposed to make a daily report of the gradations. A laboratory test, however, is essential to ascertain the presence of any deleterious matter in the sand.

2. Test for loam and silt content in sand. This can be made in the field and checked up by the laboratory results. For the loam test, an excess of water is added to a given quantity of sand in a glass graduate, the whole is well agitated and allowed to stand until the loam and silt has settled on top, when their percentage may be measured.

3. Test for set. This is made by mixing the sand with cement and forming a pat with thin edges. By breaking the edges after 24 to 48 hours it may be determined how the material sets.

4. Tests of stone and gravel. Field determinations of these materials can be made only for voids. Visual inspection should of course detect soft material and dirty aggregates.

Field Tests of Concrete

Concrete from a batch mix is made up on the road into 6-in. cubes two in number from every 500 cu.yd. of material. They are cured for 21 days in moist sand and then shipped into the laboratory and tested at 28 days. The results of these tests are given to the engineers on the work and the rivalry to have the highest test value produces good results. It is expected that these cubes shall go over 3000 lb. per sq.in. compression, and if they don't we look for trouble. Of 504 cubes tested in 1916 only 13¼% tested below 3000 lb. Nearly 90% of these failures were from dust or silt coated coarse aggregate, and from fine aggregate leaving an excess of loam or made up of excessively fine grained sand.

These tests also showed an average of 3370 lb. compression for all 1 : 1½ : 3 mix cubes, stone and gravel aggregates, while the average for the stone aggregate cubes was 3380 lb. and the average for the gravel aggregate cubes was 3080 lb. Thus it is demonstrated from these tests that stone concrete is 11% stronger than gravel concrete. In comparing the two, it is fair to say that all gravels with a coating that ordinary washing will not remove should be rejected; while stone that retains much of the dust of fracture is bound to make weak concrete—this is especially true of all soft limestones, and of any stone that is crushed when it is wet.

Suggestions on Construction Details

An exact subgrade is necessary to save the concrete that would be wasted in leveling inequalities in the foundation. The extra time and attention spent on getting an exact subgrade will be well repaid. Steel forms, while more costly than those of wood, are far more economical in the long run and pay for themselves in a short time.

The concrete should be well spaded and kept high above the screed or strikeboard on the mixer side. Tamping should not be allowed. In screeding, the screed should be slowly pulled back and forth, advancing it slowly with each operation. When approaching a joint the screed should be brought up to the joint and carried back in order that the surface may be uniform. No more floating than is absolutely necessary should be resorted to as the primary object is to have the wear on the surface taken by the stone, and not by the thin mortar layer produced by floating.

Notes from Field and Office

Flat-cars remove spoil from building excavation in New York—Hauling stone by motor truck—Cost of small sewer system—Steel derrick of box-plate section

Trains of Standard Flat-Cars Remove Spoil from New York Excavation

The deep excavation for the Commodore Hotel at 42nd St. and Lexington Ave., New York City, is almost entirely in rock. The southern portion of the site is crossed by a subway link connecting the new Lexington Ave. subway with the old line on Park Ave. The standard depth for the excavation is about 50 ft. below street level, except for a strip 75 ft. wide, extending the full 275-ft. width of the site. This latter portion will go down 100 ft. below street level and will contain a power plant designed to serve as an auxiliary to the 50th St. plant of the New York Central.

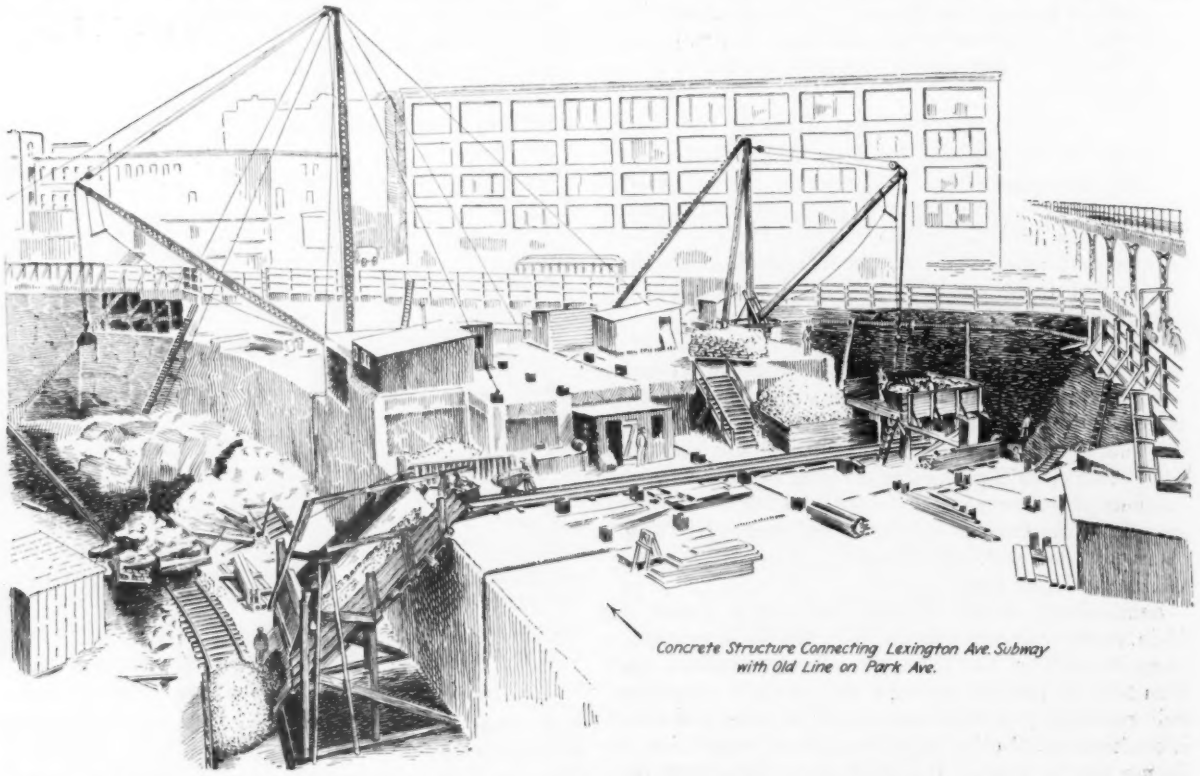


FIG. 1. HANDLING SOFT MATERIAL FROM SOUTHEAST CORNER OF COMMODORE HOTEL SITE, NEW YORK CITY

To drill the rock, 21 "Jackhamers" are used. A steel-sharpening shop is maintained on the job. The compressor—housed in the central shanty, Fig. 1—is a 1200-cu.ft. "Imperial," driven by a 200-kw. electric motor. After shooting, the small pieces are loaded by hand into large three-sided skips, which are lifted by derrick and dumped into flat-cars having capacity for about 11 yd. each. The larger pieces of rock are lifted out of the excavation by chains attached to the derrick line. Three stiff-leg derricks handle rock from the deep pit, or rather pits, as there is a rock partition left in to carry one of the standard-gage loading tracks, shown at the left in Fig. 1. The other track is now carried across on a trestle.

The material in the southeast corner, shown at upper right in Fig. 2, is earth and loose rock. This corner is separated from the rest of the excavation by the concrete-inclosed subway. This soft material is loaded by hand into dump-buckets, which are lifted by the derrick shown at the right and dumped into the hopper seen at the far right. This hopper discharges into dump-buckets mounted on four-wheel trucks running on a pair of tracks. The buckets are pushed by hand and dumped into the wide chute. When no flat-cars are available, the chute is blocked by a gate. Otherwise it discharges directly into the cars.

A fifth derrick is mounted on the subway structure. It is of the steel guyed type and like the others loads rock onto flat-cars. A long-boom derrick car was built on the job and is moved about wherever desired. Until

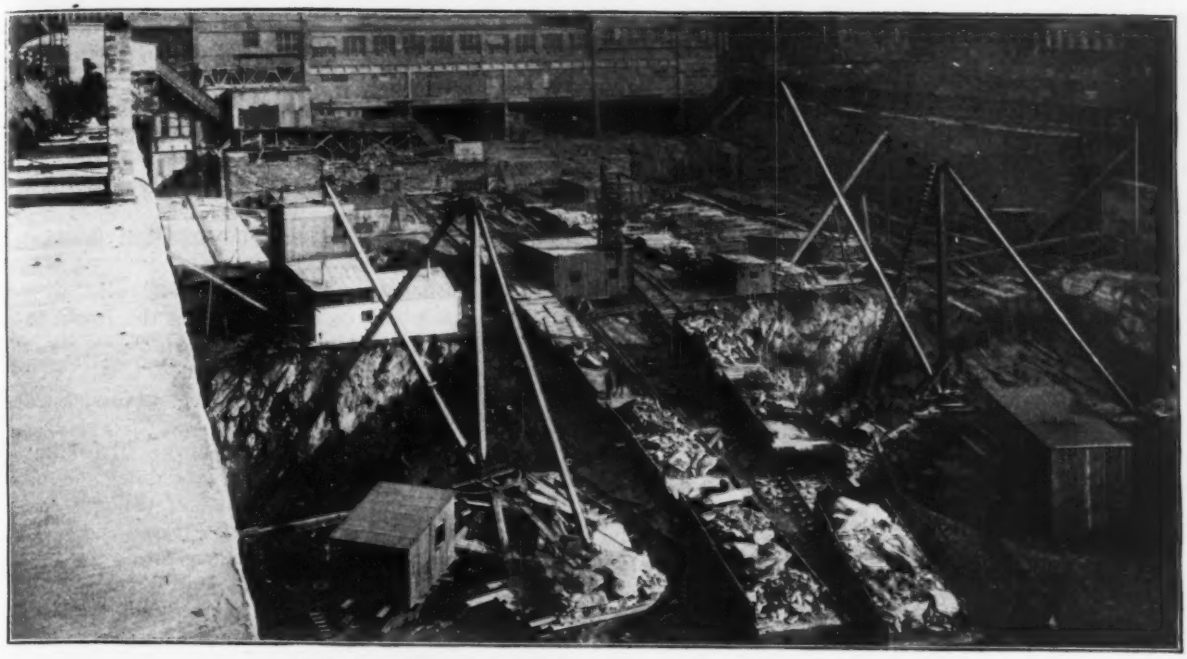


FIG. 2. GENERAL VIEW OF SITE, LOOKING NORTH, JAN. 8
Deep excavation is for power plant. Brick stack at left is composed of sample face bricks laid up for observation. Flat cars leave site by way of exit shown in Fig. 3

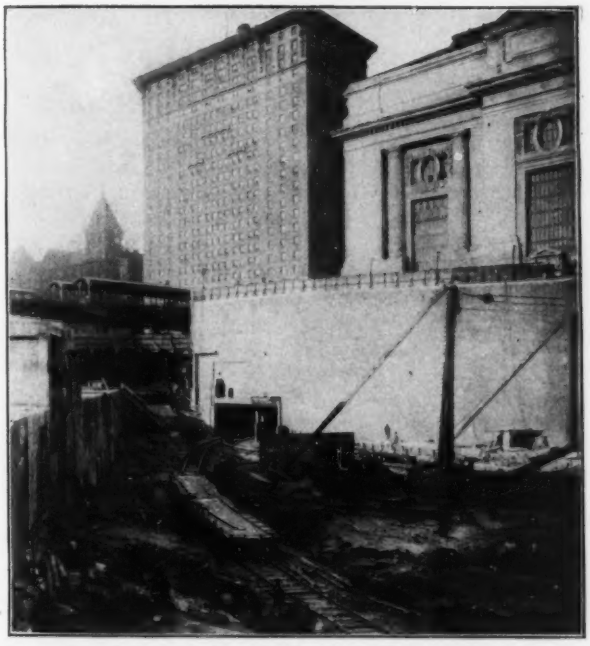


FIG. 3. SHOWING CONNECTION OF SITE WITH GRAND CENTRAL TRACKS

recently there were three loading tracks; one of these has now been taken up. The spoil is being removed at the rate of 400 or 500 yd. per day. Its disposal is simple and cheap on account of direct railroad connection by tracks leading through an opening in the side foundation wall of the Grand Central station, as shown in Fig. 3, to a point on the New York Central line about 40 mi. from New York, where it is used for fill in railroad construction.

The work is being done by the George A. Fuller Co.; D. L. Norris is superintendent on the job.

Hauling Stone for Macadam Roads by Motor Trucks in New Jersey

By James Logan*

Motor trucks of various body capacities have been used on several road contracts in Burlington County, New Jersey, during the last two years, and the experience gained here shows that the cost per ton-mile of hauling road material is about half the figure for teams and indicates in what way maximum economy may be secured.

The dumping-body truck was employed in each case. Trucks of five and ten tons' capacity used on the same job have shown that the smaller capacity is more efficient for short hauls. Stone, when loaded from cars by an unloader, can completely fill the body of a two-ton truck without reversing the position of the truck. The five-ton body is loaded on one side and then has to be turned around and loaded on the other side.

Trucks with power and manual-dumping machinery are each well adapted for certain tonnages—the manual for light capacities and motor lifts for large trucks.

To obtain high efficiency, stone must be ready in the bins of the unloader and trucks must haul over a hard surface. Motor trucks for transporting stone on short hauls should be able to maintain a speed of 15 mi. per hr., should be equipped with steel body and be capable of being readily unloaded. The operation should be such as to warrant the continuous use of vehicles. The truck should never be permitted to stand idle, but should move from cars to road, unload immediately and return to cars again without loss of time.

The character of available roads will influence the cost of hauling. The writer has observed a light truck hauling one ton of material with difficulty on a sandy subgrade, and five tons being hauled with ease at a high rate of speed on a hard compacted gravel foundation.

*County Engineer, Burlington County; Mt. Holly, N. J.

After the material has been hauled to place, the body of the truck may be raised and the end board partly opened so that the stone will fall out in a uniform layer as the truck is started forward. This has been found a very economical way of spreading stone, but it requires practice to attain the correct thickness of the course of material.

The ability of the operator is important; an experienced man will reduce the repair item to a minimum, while a careless driver will increase the cost of hauling by 2c. per ton-mile through excessive bills for parts and repairs. An idle motor vehicle being repaired at the rate of 60c. per hr. is expensive equipment. On the Burlington County work, repairs to trucks were confined to engine, bearings and gears—all of which trouble could be directly connected with the chauffeurs. The repair item may be materially lowered by rewarding with a bonus the drivers who keep the repair bills on their truck below a stated sum.

On the Jobstown Pike near Mount Holly, N. J., four two-ton Autocar trucks, from Sept. 29 to Nov. 29, 1916, inclusive, hauled 3209 tons of 2½-in. broken stone, 1714 tons of 1½-in. and 250 tons of screenings, making a total of 5274 tons. During that time repairs and overhead charges amounted to $506.03, operating expenses were $373.87 and fuel $460, making a total cost of $1339.90. This sum divided by the total tons gives a unit hauling cost of $0.254 per ton of stone. The average round-trip haul was 5 mi. This reduces to a cost of $0.0508 per ton-mile. (It is noticed that repairs plus overhead form the largest item, and these were the expenses that required vigilance.)

On this road contract, which included the rebuilding of a gravel road with 18-ft. macadam, it was necessary to use teams for hauling gravel for binder and shoulders. These teams hauled two tons to a load and made 20 mi. per day. Five dollars a day was paid for a team; therefore, it cost 12½c. per ton-mile to haul that material. This seems to afford a fair comparison with the above figures, as the trucks and teams were in use on the same work at the same time and under the same supervision. The contractor was Charles T. Eastburn Co., of Yardley, Penn. S. M. McFarland was supervisor, and the writer was engineer. Funds for the work were allotted by the state from motor-vehicle fees.

Cost Figures of a Small Sewer System

The cost of the sewerage system of the boom city of Kingman, Ariz., is sent by J. B. Wright, County Engineer. Kingman was the depot of supplies and the stopping place for prospective millionaires during the recent gold-mine rush for Oatman, Ariz. The only water-supply of Kingman was from wells scattered over the town, and the congested living conditions soon made this source of supply so dangerous that the Mohave County Board of Health took prompt and decisive action.

There was in the county treasury a fund of $10,000 to be used for health-protective measures. It was decided to begin at once the construction of a sewerage system. Plans were made for over 30,000 lin.ft. of pipe sewers, serving about 2000 people, with a limit of 7000. Construction was begun in July, 1915, with the small fund on hand, and continued until this fund was exhausted.

As soon as a line was completed and placed in service the Board of Health ordered the adjoining houses to be connected, charging the following rates for connection: Dwellings, $30; lodging houses, $40; restaurants, $50; laundries, $60; garages, $70; hotels, $80; and other classes of buildings by special agreement, according to service rendered. The funds derived from these connections were credited to the sewer fund and furnished means for continuing the work at intervals until practically the whole town was sewered.

The connections are being made practically as fast as the plumbers can do the work, and the funds paid in for connections will ultimately return the entire cost to the county. All plumbing installed is inspected and conforms to the standard for plumbing in various other cities.

The total amount of sewer constructed is 31,707 lin.ft. at a net cost of 63.3c. per lin.ft., making the total cost $20,073.50. Following are some of the unit costs: Survey and supervision, 3.83c. per ft.; trench and backfill (7400 cu.yd.), 25.59c. per ft.; distributing pipe and manholes, 1.97c.; hauling gravel and cement, 1.04c.; laying pipe, 4.57c.; building manholes and lampholes, 2.21c.; cement, 2.66c.; miscellaneous expense, water pipes, etc., 1.539c.; sewer pipe and fittings, 17.59c.; flush tank, siphons, manhole and lamphole covers, 2.31c. per lin.ft.

Steel-Frame Derrick of Box-Plate Section for Steel Erection

A large guyed derrick with boom and mast of box-plate construction instead of the more common box-lattice construction was employed in the erection of some of the steelwork in the addition to the Morrison Hotel, at Chicago. It was used particularly in erecting the heavy trusses that span the office and other open spaces of the lower floors and support the interior columns of the upper floors. The John Griffiths & Son Co. has the

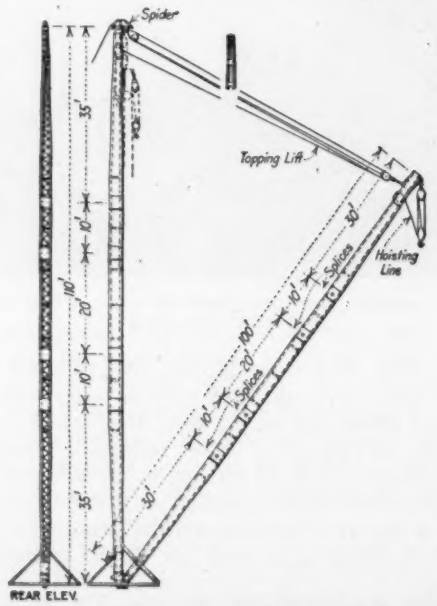


FIG. 1. STEEL DERRICK OF VARIABLE HEIGHT AND REACH

contract and depends upon its lighter box-lattice derricks for the ordinary structural work, but for the heavier work it borrowed this box-plate derrick from the Ketler-Elliott Erection Co. Both of these are Chicago firms. Fig. 2 shows the derrick in use, and Fig. 1 shows the general design.

The details of mast and boom are given in Fig. 3. The mast has two end sections 35 ft. long, two 10-ft. intermediate sections and a middle 20-ft. section. These are put together with ¾-in. bolt splices to provide for varying the height, the maximum extension being 110

FIG. 2. DERRICK OF BOX-GIRDER CONSTRUCTION ERECTING STEEL FOR MORRISON HOTEL, CHICAGO

ft. The boom is built in the same way, but has 30-ft. end sections, making a maximum length of 100 ft. All the rigging is of ¾-in. wire rope. The hoisting capacity at maximum reach (about 90 ft.) is 15 tons. As used at the Morrison Hotel, the mast was 90 ft. high and the boom 80 ft. long. The hoisting capacity was 25 tons at the maximum reach of 70 ft. The derrick lines were operated by an electric hoist with 50-hp. motor.

The boom is about 20½x27 in. at its largest section, having two 26-in. side plates and 20-in. top and bottom plates, all $\frac{5}{16}$ in. thick. There are four corner angles, all 2½x2½x¼ in. The bottom angles are inclosed within the box, but the top angles have outside upstanding legs, as shown by the section. At intervals there are

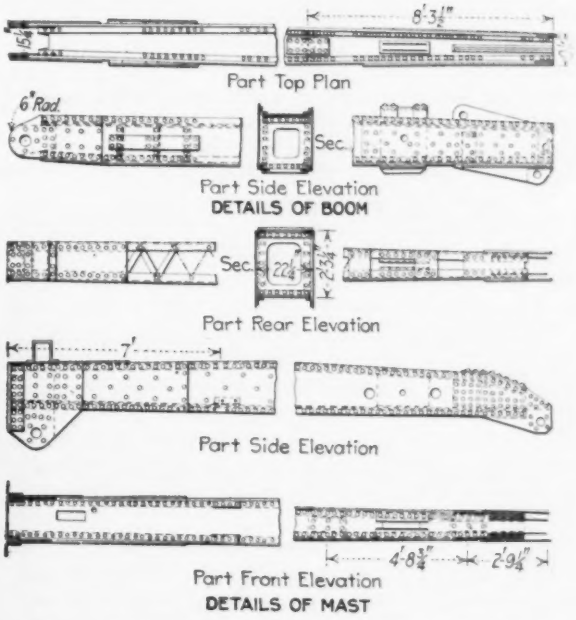


FIG. 3. DETAILS OF BOX-GIRDER BOOM AND MAST OF DERRICK

interior diaphragms, each consisting of a web plate (with large hole) and four angles that are riveted to the plates of the boom. The boom turns on a 4-in. shoe pin fitted to shoe plates on the mast and has a 22-in. sheave at the heel. To the head are attached two link-and-pin attachments for the blocks of the topping-lift and hoisting lines, and near the head is a 24-in. sheave for the hoisting line.

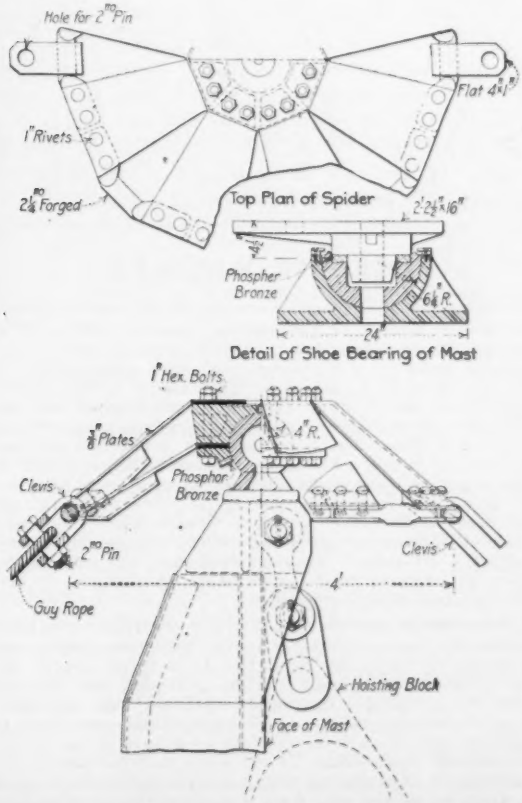


FIG. 4. SPIDER AND SHOE OF GUYED DERRICK

An important feature is that the boom can be raised to a vertical position, standing with its head against the mast. This is made practicable by extending the pin plates for block attachment at the head of the mast to carry the topping-lift attachment forward of the face, so that the topping lift hangs vertically in front of the mast when the boom is raised to its limit.

The mast is about 22¾x30 in. at its largest section. Unlike the boom it has one latticed, or open, side, this being the back. The two front angles (with outstanding legs) are the same as in the boom, but the rear angles are 3½x3 in., with the lacing on the inside. The lacing is of bars 2¼x⅜ in. and 2½x½ in., and angles 2½x 2x¼ in. The front plate is 22x¼ in., and the two side plates are 30x¼ in. The diaphragms are each composed of a $\frac{3}{16}$-in. plate (with hole about 14x17 in.) and four angles. The mast has a 13½-in. sheave at the base and two similar sheaves and a 16-in. sheave near the top. At the top also is a link-and-pin attachment for the block of the topping lift.

The spider at the head of the mast is of unusual construction and is shown in Fig. 4. It consists of two dished plates cut to form eight radial arms, with narrow spaces between. The plates are riveted together at their outer edges, with fillers between them. Each filler extends across one of the open spaces and has this portion rounded to receive a U-shaped clevis for the attachment of a guy line. At the center of the spider is a casting with hemispherical bearing on a 4-in. ball riveted upon the top of the mast.

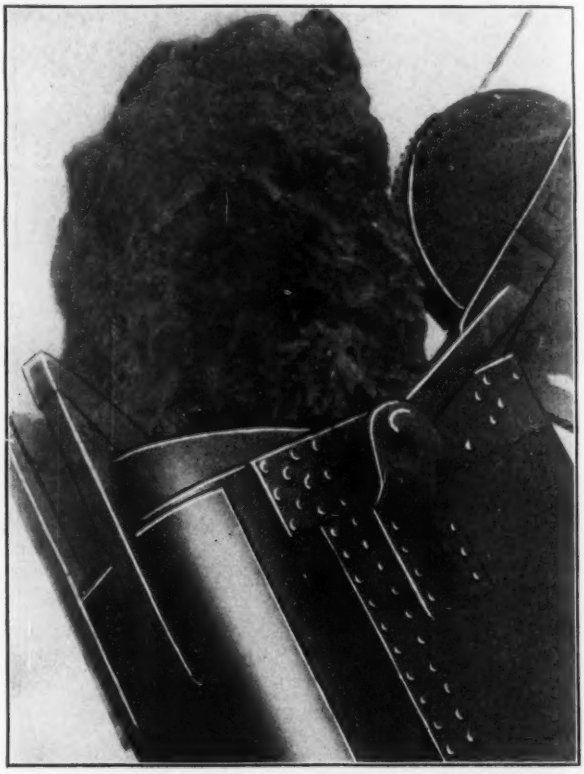
The base of the mast has a casting with a hemispherical bearing of 6¼-in. radius in a cast-steel shoe. To the shoe is attached a bull-wheel 7 ft. in diameter, having its rim made on a 5-in. channel with web inward. This is carried by two horizontal members riveted against the mast, each consisting of an inverted 5-in. channel with an angle 3x2½ in. riveted inside the web. Horizontal angle braces extend from these members to the circular channel, and diagonal braces in a vertical plane extend from this channel to the sides of the mast. On the back of the mast is a loop to carry a cross-timber for swinging the derrick by hand.

FINE AGGREGATE

The Short Method of Calculating Areas given by C. K. Averill in "Engineering News," Dec. 21, 1916, p. 1186, is not of general application to three- and four-sided areas. It should have been so stated, although a glance at the demonstration given makes it apparent that the method will not hold for four-sided figures containing a reëntrant angle; and as Prof. E. F. Chandler (University of North Dakota) has pointed out, it is true only if in traversing the perimeter of the figure no two sides run forward in directions that are in the same quadrant. The method is correct only in the special case illustrated, of a figure of such shape that each side cuts off a complete triangle from the inclosing rectangle formed with the sum of the departures and the sum of the latitudes of the given figure as its base and altitude. In this case the method is very convenient.

An Electrolysis Survey of the entire distribution system of the Boston Metropolitan Water and Sewerage Board was made during the latter part of 1915. As in former years, the results show differences of electric potential and electric currents of considerable magnitude resulting from the operations of the electric railways. No excavations were made in conjunction with these measurements to determine the extent of the electrolytic corrosion of the pipes, but the policy has been continued of installing wooden insulating joints about 500 ft. apart on all new pipe lines to prevent the accumulation of large electric currents on the pipes. None of the water mains has been recently destroyed. The city has detailed a man to make tests at certain stations where current is known to be flowing and to gather other data in regard to this work. There has been no known damage to the city water mains for some years, but services are occasionally destroyed, mainly in Dorchester and Roxbury. The telephone company and the lighting company have had no trouble of a serious nature on cables within the past five years; each makes frequent or regular tests, and cables are bonded to railway returns. The traction company has a regular detailed force for making tests and examinations of trouble and damage reported to subsurface structures; such surveys as are made have the coöperation of the telephone company. Information from the several sources indicates that recent electrolytic damage has been slight, but the tests and the measures taken to prevent trouble evidence the presence of stray electric current in the ground.—Report of the National Board of Fire Underwriters, December, 1916.

A Big Coral Boulder scooped up by a dredge in the Hawaiian Islands is shown in the dredge bucket in the accompanying view. The boulder was so large that it could not



BIG CORAL BOULDER IN DREDGE BUCKET

be gotten through an opening 9x14 ft. This material weighs about 2,700 lb. per cu.yd.

Patching Concrete Pavement, at Charlotte, N. C., is accomplished with an outfit which includes a Hooke portable asphalt plant, having a capacity of 21 cu.ft. to a batch, one wagon and team, three laborers and the necessary tools and appliances. The asphalt mixture used in making the patches is composed of 75% sand, 10% portland cement and 15% asphalt. This is richer in asphalt than the ordinary sheet-asphalt paving mixture. Before making a patch, the concrete around the edge of the hole was trimmed back to a firm, unbroken surface. The walls or sides of the hole were made vertical and excavated to a depth of about 3 in. The hole was then thoroughly cleaned out, and the sides and bottom were painted with melted asphalt. The sheet-asphalt mixture, heated to about 300° F., was then deposited, compressed by tamping, finished with a hot smoother and dusted over with cement. In every place the asphalt patch has remained intact, showing no signs of spreading or giving way. New holes have been worn in the concrete pavement at other places, in the meantime. The asphalt plant was conveniently located on other work, so that no time was lost in firing up or moving. There was no waste in having surface material left over. The area covered by patches was 4.54 sq.yd., and the unit cost was 63c. per sq.yd.

Editorials

Uniting the People of the United States

History has been made very rapidly since the last issue of *Engineering News* went to its readers. The Government of the United States and its people have been confronted with the necessity of making prompt and wise decisions in one of the most momentous situations that has ever confronted the nation. There have been deep and broad differences of opinion here on matters connected with the war and on other matters that have seemed to gravely threaten our national welfare. In the responsibility now confronting us these differences have all but disappeared. Almost with one voice men of all parties and all factions have avowed the determination to stand by the President in any step he may take for the defense of American rights. A remarkable illustration of this occurred at the Republican Club in New York City on Feb. 3. The Chairman of the Club declared that partisan politics stop at the water's edge. Elisha Lee, representing the associated railways of the United States in their dealings with the railway brotherhoods, and W. S. Stone, Chief of the Brotherhood of Locomotive Engineers, declared at this time of national stress the railways and their employees will find ways to settle their differences without interrupting the country's business.

In no calling or occupation will a more universal spirit of loyal patriotism be found than among the men of the engineering profession. A very large proportion of them have been actively interested in plans for developing true preparedness in the nation, through the great inventory of American factory plants and through other means. In the present national emergency the Government can count on the whole-hearted support of the engineers of the United States, and that their services are greatly needed in many departments of the nation's work there is no room for doubt.

Engineers Protest Against Electric Drive for Battle Cruisers

A strong body of expert opinion is opposing the decision of the United States Navy Department to adopt the electric drive on the four new battle cruisers for which the Government is now seeking to let contracts. These vessels are designed to be the largest and fastest first-class warships ever built. Each of them is to have boilers and engines capable of developing 180,000 hp. The Department proposes to equip these vessels with the electric-drive system, the plans involving steam turbines driving four electric generators, each of 45,000-hp. capacity. These furnish current to eight electric motors mounted directly on the propeller shafts.

When the bids were submitted for these cruisers, the Fore River Ship and Engine Co., whose President, J. W. Powell, was formerly a United States naval constructor, offered to build the vessels at a much lower figure, provided geared turbines were substituted for the electric drive. It was pointed out that among other objectionable features of the department's design is the location of about half the boilers in the vessel above the protective deck, where they would be liable to penetration in case the vessel was in action.

Dr. Schuyler S. Wheeler, President of the Crocker-Wheeler Electric Co., in a letter which was published in the New York *Sun* of Jan. 29, severely criticizes the Navy Department for its adoption of the electric drive on these important vessels, without obtaining independent expert opinion in the matter. Dr. Wheeler says:

> These huge electrical machines, carrying enormous currents of electricity, with their cables, rheostats, switches and switchboards, and other complicated electrical apparatus, bulky and at the same time delicate, likely to be short-circuited, cut by splinters or otherwise, and in many other ways put out of service, are a new and almost wholly untried experiment. No other country is using electric drive for warships.

Dr. Wheeler urges with great force that Congress should not approve this huge experiment by the Navy Department until it has been investigated by a board of independent engineers, competent to advise on the technical questions involved. It appears that the Naval Consulting Board, which is now an official body, has not been asked to express an opinion at all in the matter and that the whole big experiment, involving vessels which will cost probably over $80,000,000 and will take presumably over four years to construct, has been handled apparently as a mere routine matter by the officers of the Bureau of Steam Engineering.

With all due respect to these officers, it is a fact which hardly permits dispute that they have not had the breadth of experience in the use of electric machinery of the largest size that would make them competent to pass upon such a technical question. Dr. Wheeler is one of the pioneers in the electrical industry, a past-president of the American Institute of Electrical Engineers, and his protest obviously is one that cannot possibly be lightly passed over.

Secretary Daniels is now appealing to Congress for several million dollars' additional appropriation to enable the contracts for these vessels to be let. A large part of this additional cost is unquestionably due to the adoption of the electric drive.

These are times when the Government and all its officials must seek by every means to retain public confidence. Engineers, who can fully appreciate the great responsibilities and difficult tasks that the members of the profession in high Government positions have to carry, have no desire to criticize needlessly. They are fully aware, however, that grave mistakes have been made in the past in many matters of Government administration in which their own profession is involved; and in this period of national crisis it is surely proper to urge that the engineers of the army and navy should not fail to avail themselves of the expert knowledge of civilian engineers.

Building Well and Operating Poorly

Spending money unstintedly for construction, often under the supervision of the best engineers the country affords, and then being niggardly in maintenance and operation appropriations and leaving costly and perhaps complicated works to run themselves except for political heelers or lame ducks is the rule rather than the exception in many if not most American cities.

The foregoing reflection is prompted by the following sentences from the annual report of the Connecticut State Board of Health for the year ended Sept. 30, 1916 ("Monthly Bulletin," Connecticut State Board of Health for January; Hartford, Conn.):

> Large sums have been expended by municipalities and towns installing works for the treatment of sewage which might just as well have never been expended, because, for the lack of skilled supervision and intelligent operation, the results, as far as conserving the purity of our streams, have been negligible. When we realize that out of sixteen municipal and town sewage-treatment plants in the state but three are disposing of sewage satisfactorily, immediate action should be forthcoming.

That Connecticut is not alone in this matter is of course no reason why her legislators should not give her State Board of Health the control over sewage-treatment works that it pleads for in the report mentioned. The legislature recently put new responsibilities upon the board as regards "sewage disposal, stream pollution and watersheds," but provided no funds with which to perform those responsibilities—a characteristic legislative habit. Some advance has been made in health legislation, and Governor Holcomb, in his inaugural message, advocated a reorganization of the State Board of Health and an appropriation for its work "sufficient to give our state a health administration adequate for modern needs." The engineers of Connecticut should do their part to induce the legislature to carry out the recommendations of the governor.

Engineers as Publicity Experts

The work done by a committee of the Engineering Association of the South in bringing to the attention of President Wilson and of Congress the advantages of Muscle Shoals as a site for the Government's nitrate plant was briefly recorded in a recent issue; but the achievement deserves something more than passing notice, for it demonstrates what engineers may accomplish in a field which has been often held to be no proper part of the engineer's work—the field of publicity.

The work of publicity is generally associated in the mind with the advertising of goods for sale; but that is only a part of what publicity includes. Publicity may be broadly defined as the systematic influencing of men's minds on a large scale toward a definite end.

Most engineering works of the present day must have a prepared foundation of publicity before a beginning can be made in the work of construction. It is too often assumed that this publicity work is no part of the engineer's business; but as a matter of fact, if he does not at least aid in it by furnishing facts and figures, there are likely to be serious flaws in the foundation.

It is common to hear engineers complain because the public awards the honor for a great engineering work to the promoter and not to the engineer who does the technical part of the work. But the public discerns what the engineer often fails to see, that the work of overcoming the inertia of men's minds is often a more difficult task than the work of shaping steel and earth and rock, which the engineers accomplish. There are a score of great engineering enterprises in the United States today which are known to be practicable and profitable, but whose realization depends on the coming forward of the genius who will persuade men's minds that the thing can and should be done and show them the way to do it.

The promoter is the man who sells the engineer's services. The engineers who have achieved widest fame and largest fortune have been those who have discerned this and who have been able by promoting their own enterprises to fix their own rates of compensation.

There is no lack of illustrations to show that engineers from the earliest days have been able to succeed in the work of publicity. The Stephensons, famous among the pioneer railway builders of England and the Continent, were chiefly occupied, not with the technical problems of actual construction, but with the task of convincing the investing public and parliamentary committees of the merit of their enterprises. Captain Eads, the builder of the St. Louis bridge and the Mississippi jetties, is remembered by the public because of the publicity which he secured for his great enterprises.

These are examples from great and well-known works, but there are countless examples among the smaller enterprises where engineers have themselves done the foundation work publicity and reaped the reward. The work done by the engineers of Nashville and vicinity to demonstrate the advantages of the Muscle Shoals site is notable because it has been done as a free contribution to the public welfare, something which has been much talked about as the duty of the engineering profession but of which no great amount has been actually accomplished. It is also notable because it is a remarkable illustration of efficient publicity work. The booklet which these engineers produced was carefully planned to arouse the interest of the recipient at the start and to hold his interest until he comprehended the main facts, at least, which it was the aim to impress upon his mind.

Commission-Manager Plan of Vital Interest to Engineers

The keenly intelligent analysis of municipal administration now going on throughout the country is bound to react favorably upon the status of engineers. Particularly encouraging is the rapid progress of the commission-manager plan.

The commission plan alone is a marked advance on earlier forms of municipal government as they have worked in the United States, but the plain commission system has elements of great weakness. Some of these have been pointed out more than once in these columns, but they affect the engineer so vitally that they will bear repetition—all the more when it is possible to present a fresh statement from a new source which at the same time illustrates the widespread keen intelligent interest in municipal affairs already mentioned.

Speaking on opportunities for increased municipal efficiency before the Helena Commercial Club on Jan. 24, Henry Gerharz, United States Surveyor General for Montana, reviewed the growth of the commission and

commission-manager plans of city government. He quoted with approval sentiments expressed editorially by the St. Paul *Pioneer Press* of Jan. 14, 1917, after experience with the commission plan in that city. That journal declared that while "widespread experience approves and justifies the system in most of its essential principles," yet it is agreed by students of the plan that some lacking element "has operated to prevent the fullest results rather than condemn the system." This lack, the *Pioneer Press* believes, is met by adding the city manager, "so the city's affairs are conducted exactly as are the affairs of a large business concern."

Mr. Gerharz's own concise and apt summing up of the fundamental principles that make the commission-manager plan superior to the commission plan is as follows:

> The people (stockholders) elect a commission (board of directors) who hire a city manager (general manager) who appoints and directs the employees. This plan gives a strong single-headed executive presiding over all departments, coordinating their activities and acting as a court of appeal in case of friction or rivalry between the different departments.
>
> The people can select, as commissioners, representatives who will truly represent their class or walk of life without being hampered by any thoughts of his business experience or salary-earning capacity. These representatives can act more intelligently through a manager than if they were individually compelled to assume the direction of a department. Membership in the commission becomes attractive to the ablest citizens, since it offers an opportunity for great usefulness without interrupting their private careers or business.

It would be difficult to give better expression in reasonable compass of the essentials for securing a combination of representative government with efficient government. That an engineer has done this so admirably in the course of a luncheon address should be a comfort to those who bewail the silence of the engineer on public questions or, admitting that he speaks now and then, deny his ability to speak well.

Do any of our readers ask why the engineer, as such, is vitally concerned in the adoption of the more efficient of the two forms of government? If so, the reply is that under the straight-commission plan the heads of administrative departments become such by either the chance of popular vote or else on agreed division of duties among the commissioners themselves after election. These commissioners soon feel themselves qualified as "experts" in the various matters under their control. As their importance grows upon them, they relegate technical and professional men to the rear. Under the commission-manager plan the manager selects all department heads. If he is not himself a professional man, the chances are that he appreciates the value of such men and is willing to pay them accordingly.

Finally, many of the city managers, including those of greatest achievement, are engineers. This will probably continue to be the case for some years. This is one reason, even if not the most notable, why the commission-manager plan vitally concerns engineers.

Shall the Work of Railway Valuation Be Left Incomplete?

For nearly four years an army of engineers has been engaged in making an accurate valuation of the entire railway system of the United States. The work has been done under the terms of a law enacted by Congress in 1913, and it has been the universal belief of the public, and doubtless of the engineers engaged in this work, that the final result would be an authoritative determination of the value of the different railways.

Now comes the surprising announcement, made by Director C. A. Prouty in a hearing before the Interstate Commerce Commission last week, that it is not the present intention of the commission to make any final determinations of valuation. What the commission intends to do, apparently, is to announce the detail results of the inventory that it has made, in the same manner as in the case of the two Southern roads, the Texas Midland and the Atlanta, Birmingham & Atlantic, for which the tentative results were announced some two months ago.

It must be said frankly that there is some support for this attitude of the commission in the phraseology of the law enacted by Congress in 1913. That law, as was pointed out in this journal at the time (*Engineering News*, Nov. 9, 1913), required the commission to ascertain for each railway the cost of reproduction new, the cost of reproduction less depreciation, and also the original cost of lands, rights-of-way, etc., used, and the amount of gifts, bonuses, etc., received by the company; but the law did not indicate what use, if any, was to be made of these diverse elements, although Section 5 of the law says that the commission "shall show the value of the property of every common carrier as a whole," the term "value" being popularly understood to mean what it would cost at the present time to replace the property in its present condition. The work of the commission in valuing the country's railways will unquestionably fall far short of the full measure of public expectation if the commission fails to make a final determination of that value in a form intelligible to the public. The separate figures of inventory which it has compiled do indeed furnish the data from which such a valuation could be made; but the public has for years been looking to the commission as the authority for fixing earning and acquisition bases, and the public would rather have its judgment as to what shall or shall not be included in the final valuations than it would the opinion of Congress.

It may be freely admitted that these figures of value, when determined, could only rarely be of use in settling disputed rate questions, or even in fixing assessments for taxation. There are many thousands of miles of railway in the United States which are unable to charge rates high enough to enable them to earn even a very modest rate of interest on their valuation as measured by cost of reproduction, not because of any public rate regulation, but because competition and other commercial conditions make it impossible for them to charge such rates. Again in assessment for taxation, unless railways are to be taxed on a different basis from all other property, the only fair basis of taxation is earning power.

Those who have looked forward optimistically to an era of better relations between the railways and the public had hoped that the valuation by the Interstate Commerce Commission might put finally at rest all controversy as to whether the railways are attempting to earn dividends on watered stock at the present time. If the commission refuses to exercise the authority that Congress almost certainly intended to confer upon it and fails to make a final valuation of the railway property of the country, a large part of the benefit that ought to result from the vast task on which so many engineers have been engaged will be forfeited.

Letters to the Editor

Is Tension Positive or Negative?

Sir—A number of years ago the writer believed it to be a well-established custom to give the compression the plus and tension the minus sign on stress sheets of bridges. It now appears that many, if not most, of the recent graduates have been taught the opposite. It is unfortunate that confusion exists regarding this sign conventionality.

The pressure of a bridge pier on its foundation (a compressive stress) has the positive sign. The pressure of a bridge shoe on masonry is considered positive. The bearing power of a pile is positive. The pressures of liquids and gases in pipes are considered positive. Barometer pressures are positive. Earth pressures against retaining walls are positive.

If engineering science is viewed as a whole, it would appear that compression should be called plus and tension minus on a bridge stress sheet in order to be consistent with established practice in foundation design, masonry design and earth-pressure and fluid-pressure calculations.

Los Angeles, Calif. R. W. STEWART.

[An extended editorial discussion of this question was given in the Engineering Literature Supplement to "Engineering News" of Dec. 15, 1904, p. 549. The arguments are essentially: (1) Compressive stress (not presssure) should be positive because it is the predominating stress in all structures that carry load downward to a support. (2) Tension should be positive because it corresponds to stretch, or increase of length, so that with the positive sign Hooke's law for tension holds without an arbitrary minus sign. Formerly, the practice of making compressive stress positive was widespread, but in the past 15 or 20 years the tendency has been in the contrary direction.—Editor.]

Difficulties in Flood-Frequency Studies

Sir—The article relating to fixing maximum flood limits in the Miami Valley flood-protection work, published in your issue of Jan. 4, 1917, presents a very comprehensive investigation of storm occurrence in the eastern United States, for which those who conceived and carried it out deserve much credit. The investigation was made in such a new field and involved the collection of such a large mass of valuable data relating to storms that the writer believes it will be of particularly great benefit, not only to civil engineering, but to meteorologic science, if these data can be published.

The method employed for determining storm frequencies, although so well adapted to the problem, has also certain inherent limitations that should be kept in mind for a proper understanding of the results. The fundamental idea of the frequency studies is stated to be that the storm experience of one station or one quadrangle adds to that of others. In this way, it is asserted, storm incidence for very long periods of time could be studied, though the records were short-time.

The lengths of records at the 478 stations in the central basin are said to have varied from 10 to 73 years, and averaged 15.8 years. It appears, therefore, that the great majority of the records were obtained in the last 20 years. There seems to be considerable evidence that the climate has changed noticeably within the past few centuries,[1] such changes being accompanied by increase or decrease in storm occurrence. There are also those who maintain that there has been a tendency for floods to increase in the Ohio Valley in recent years;[2] and it is by no means established that if there is such a tendency it may not be due, at least in a measure, to changes in the occurrence of storms. Therefore, the storm-frequency characteristics that cover the experience chiefly of the past 20 years may be considerably different from what they would be for a 100-year period, and perhaps very appreciably different from what they would be for a 1000-year period. Because these results may be based too exclusively on the conditions of the past 20 years, a similar investigation confined to the records of longer duration would be instructive.

According to the writer's understanding, the mode of procedure described as method A would give the expected frequency of occurrence of storms of different magnitudes at one observation station; method B would give the average intensity of storms of such magnitude that they occur not oftener than once in 50 years or not oftener than once in 100 years at one observation station, and not the intensity of the storm whose average period of recurrence is 50 years or 100 years, as assumed in the article. The two ideas are quite different. Either method, it should be further emphasized, gives results applying to but one observation station and not results applying primarily to areas as large as the entire Miami basin, as is maintained in the article. This is true because the method only takes account of the total number of times a certain precipitation has occurred at certain separate stations and does not take any account of the probable frequency of the storm as affected by the area covered by it. It is stated that 35% or approximately 1225 of the storms considered covered from two to six stations, and that 15% or approximately 525 of the storms considered covered over six stations. This indicates what would naturally be expected, that the probability of a storm would decrease as the number of stations it covers is increased. So it seems to the writer that the frequency of occurrence of a certain storm over the entire Miami basin would probably be much less than the results indicated by the curves. The saving condition is that the error is on the safe side.

Furthermore, studies of the writer have impressed upon him the extreme variability of the intervals between unusual meteorologic phenomena, such as very severe storms. For example, a drought of a certain degree of intensity, which would appear to have an average frequency of about once in 40 years, may occur at intervals of any length from five years up to at least 80 years. Those storms of which the average frequency was 500 years would be expected to occur at intervals anywhere between the limits of, say, 50 and 3000 years. The records of stations in the central basin aggregate about 7550 years. Even if a 7500-year record were available at one station, it would be far too short for determining with any degree of accuracy the frequency of storms occurring at such widely varying intervals as the 500-year storm. The saving condition in this case is that storms might vary considerably in frequency from the 500-year storm and not vary very widely from it in amount, so that so far as this factor is involved the amount computed for the 500-year storm would probably not be far from correct.

It is probably quite generally accepted that the longer the record of storms the greater will be the severity of the worst storm recorded. The 1913 Ohio Valley storm was very unusual, whether it was such a storm as will occur once in 50 years on an average or once in 1000 years. By basing the flood limit on a storm 40% greater than the 1913 storm, Fuller's formula,[3] which makes the maximum flood flow vary as 1 + 0.8 log T, where T is time in years, would make a storm 40% greater than a storm occurring once in 50 years a storm such as would occur once in 700 or 800 years, while a corresponding increase in the 1000-year storm would make it such as would occur about once in 50,000 years. Likewise, a statistical analysis of storm frequencies indicates very conclusively that a storm so much greater than that which occurred in 1913 is for all practical considerations outside the realm of probability.

The writer believes that the frequency curves present in concise form the tendencies in the variation in frequency of storms of different magnitude at one observation station, but that as representing actual frequencies as they would be obtained from records over very long periods of time there is a possibility that they may be appreciably in error; at least, it cannot be satisfactorily demonstrated that they are not. Furthermore, it is believed that they present results which are probably over-conservative for application to areas of the size of the Miami basin. The large "factor of ignorance," which is certainly wisely introduced in a problem of this kind, dispels all possible doubt as to the conservatism of the assumption as to the maximum flood limit. R. W. DAVENPORT,

Assistant Engineer, United States Geological Survey.

Washington, D. C., Jan. 17, 1917

[1] Discussion by E. Huntington, "Journal" of the American Water-Works Association, Vol. 3, No. 1, p. 94.

[2] "Floods," M. O. Leighton, United States Geological Survey Water-Supply Paper No. 284, pp. 10-27.

[3] "Flood Flows," Weston E. Fuller, Mem. Am. Soc. C. E., "Transactions," Am. Soc. C. E., Vol. 77, pp. 564-694.

Activated Sludge at San Marcos, Tex.

By Henry E. Elrod*

In regular daily service in San Marcos, Tex., there is a practical and highly satisfactory activated-sludge sewage-disposal plant having a capacity for treating 150,000 gal. of domestic sewage per 24 hr. The plant was designed and built by Ashley F. Wilson, engineer-manager for the San Marcos Utilities Co., and has been in operation since about Sept. 1, 1916.

The plant (the general arrangement of which is shown in Fig. 1) consists of an aëration tank 16 ft. wide by 40 ft. long and about 8½ ft. deep from the flow line of the sewage to the top of the filtros plates. The tank is divided into four channels, each channel having a row of filtros plates 12 in. square at the apex of inverted pyramids down its center. The filtros plates are spaced 3 ft. c. to c., there being 52 plates all told. The opposite end of each channel is open, thus allowing the sewage to flow in series from the inlet at the left to the outlet at the right. The outlet opens into the settling tank, which is 10 ft. wide by 25 ft. long and 25 ft. deep, the walls having a vertical batter of 1 to 2.

Aëration is accomplished by means of a 6x10-in. Connersville blower of the Boston type, having a rated capacity for 260 cu.ft. of free air per minute under 5 lb. pressur . It is actuated by an electric motor requiring an average of 4 kw. of current. The sludge lift is operated by air from this blower.

When the plant was first put into operation, the distribution of air through the filtros plates was uniform and satisfactory. Later, however, some of the plates showed signs of erratic action. Upon investigation it

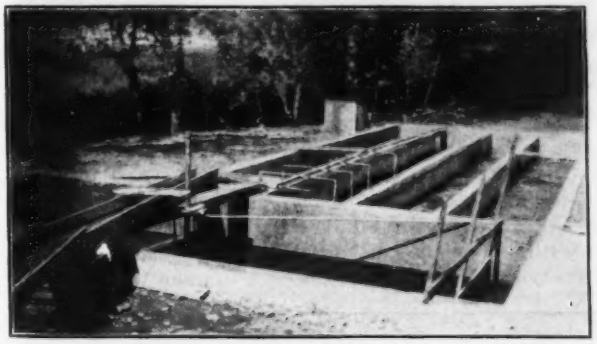
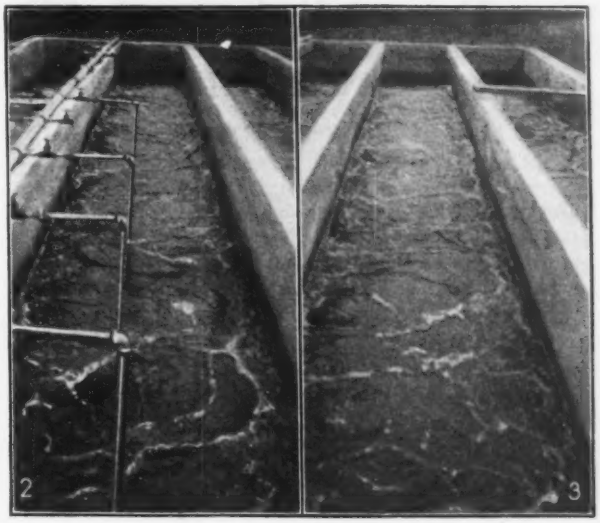


FIG. 1. GENERAL VIEW OF ACTIVATED-SLUDGE PLANT, SAN MARCOS, TEX.

was found that one corner of one plate had been cut out by the action of the air and the other plates had become choked to such an extent that their usefulness was destroyed. As each plate failed, a small pipe with its lower end open and the upper end connected to an air line was substituted with satisfactory results. Fig. 2 shows a channel with five (only four show in the photograph) such pipes in operation. Fig. 3 shows a channel with all the filtros plates operating satisfactorily. It will be noticed that there is no material difference in the ebullition at the surface of the sewage between the two channels. In the right-hand channel (Fig. 3) it will be noticed that, just under the board across the tops of the channel walls, the sewage is boiling up at a fierce rate. It is evident that the filtros plate below has failed.

*Engineer, Interurban Building, Dallas, Tex.



FIGS. 2 AND 3. PIPE DIFFUSERS AT LEFT AND FILTROS DIFFUSERS AT RIGHT

The effluent produced by the plant has a relative stability of 99%, a bacterial reduction of about 98% and is bright and sparkling, though slightly tinged with green, supposedly on account of the algæ in the municipal water-supply. The activated sludge produced is of a golden-brown color. Although the plant has been in operation for more than three months, there has been no appreciable accumulation of sludge other than that necessary to operate the plant.

The total cost of the completed plant, in round figures, was $3500, which sum included the lowering of the bottom of the settling tank after the plant had been in operation for a short time. The plant is near the city, but it produces no offense watever. The operation of the plant is simple—it requires but a few minutes' attention each morning.

Excelsior Filters in the Water-Softening Plant at Owensboro, Ky., do not appear to be giving the satisfaction previously reported or else the plant is otherwise at fault, for considerable trouble is being experienced with lime deposits in the water mains and meters. The softening plant was put in use in December, 1911. (For description see "Proceedings," American Water-Works Association for 1912, pp. 203-218, a paper by E. H. Breidenbach, then and now superintendent of water-works.) After treatment with lime and soda the water is discharged downward from a central mixing tower into the bottom of a sedimentation tank. The tank bottom slopes upward from the lower to the outer sides of the tank, where the water passes through a channel on either side filled with excelsior. This material is designed to remove such suspended insoluble matter as is not deposited by sedimentation.

Motor-Driven Street-Cleaning Equipment is growing popular in Baltimore, Md. Three additional electric tractors were purchased last year by the Street-Cleaning Department for the squeegee machines, making a total of nine motor-driven squeegees at the present time. Experience in this and other cities has shown these machines to be an efficient and economical way of cleaning smooth pavements, particularly in view of the increased cost of manual labor sufficient to clean the ever-increasing area of improved pavements being laid. In this connection the Street-Cleaning Commissioner reports that provision for an increase of 25c. per day in the pay of all laborers in his department has been made in the appropriation for the year 1917, making a total increase of $64,000 for the year in this one item alone. On the most important heavy traffic thoroughfares the squeegees are used daily, weather conditions permitting; streets in residential sections are washed four times each week. This service, particularly during the hot summer months, renders the streets cool and reasonably dustless at all times.—Baltimore (official) "Municipal Journal," Jan. 12.

Dry Mixing of Concrete Materials on Calumet Sewer at Chicago

Second-Prize Concrete Dry-Mixing Article in the "Engineering News" Prize Contest

By Benjamin Wilk*

Dry mixing of concrete materials at a central mixing plant is well illustrated on section No. 6 of the Calumet intercepting sewer in Chicago, where Byrne Brothers, contractors, have been working an equipment consisting of elevated bins, bulk cement, mules, dump-cars and narrow-gage track, which they have developed after two seasons' operation of similar plants.

One-half mile of this two-mile section of 17-ft. 6-in. concrete sewer is practically completed. All the concrete has been assembled dry at a single plant, which on account of the arrangement of the railroad tracks was located near the end of the sewer at 123rd St. and Prairie Ave., just west of the Illinois Central R.R. tracks, and transported to a traveling mixer alongside the sewer trench.

A special unloading spur was built alongside the tracks, and from it the materials are handled. Elevated wooden bins are located parallel to the spur track at such a distance away that a crane can operate advantageously between the track and the bins, in unloading the sand and stone. These elevated bins (Fig. 1), built of 2-in. lumber and supported at 4-ft. intervals by 4x6-in. posts, are 6 ft. wide, 5 ft. high and about 275 ft. long, with the bottoms 5 ft. above the ground at one end and 6 ft. above at the other end, in order to allow for the passage of cars underneath. Partitions halfway up to the top are placed inside the bins at the 4-ft. intervals, so that in effect there are a series of bins each 4x6 ft. in horizontal cross-section and 5 ft. high. At the bottom of each of these sections there is a hopper arrangement, the opening and closing of which are controlled by a lever.

Mules, ½-yd. side-dumping steel cars formerly used by the French Government at the Panama Canal, and a narrow-gage 40-lb. rail track make up the transportation system. Passing tracks are conveniently located. Six cars drawn by a single mule constitute a train under normal weather conditions. For the haul of 2000 ft. now being made, four mules are required.

Crushed stone is first dropped into each car as it is pushed along by hand on the slightly inclined narrow-gage track under the bins. The sand is similarly dropped in by a man working the levers as the car moves along to the other end of the line of bins. It is then pushed about 75 ft. to a point alongside the railroad spur, where a car of bulk cement has been "spotted" (Fig. 2). Cement measured by a wooden box of 2½ cu.ft. capacity is carried out to a platform over the car and dumped into it. The car, with its load of stone, sand and cement, is then pushed a short distance past the cement platform; and when six cars are ready, they are coupled together behind a mule. On the journey to the mixer a siding has to be taken in order to allow returning empties to pass.

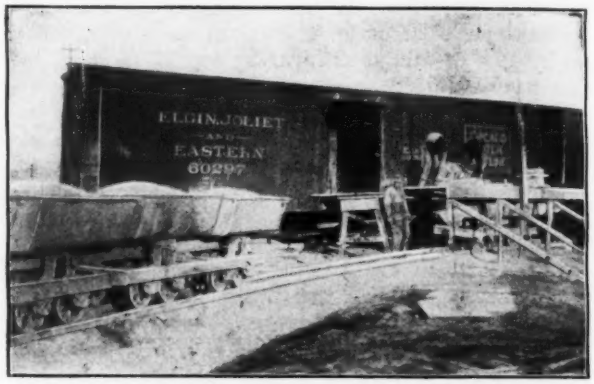


FIG. 2. UNLOADING BULK CEMENT FROM FREIGHT CARS
Narrow-gage cars at left are filled wth cement, stone and sand; cement is being added to narrow-gage cars to right. All are to be pulled in one train to mixer

Within a definite distance from the machine the cars are uncoupled and pushed one at a time up to the mixer.

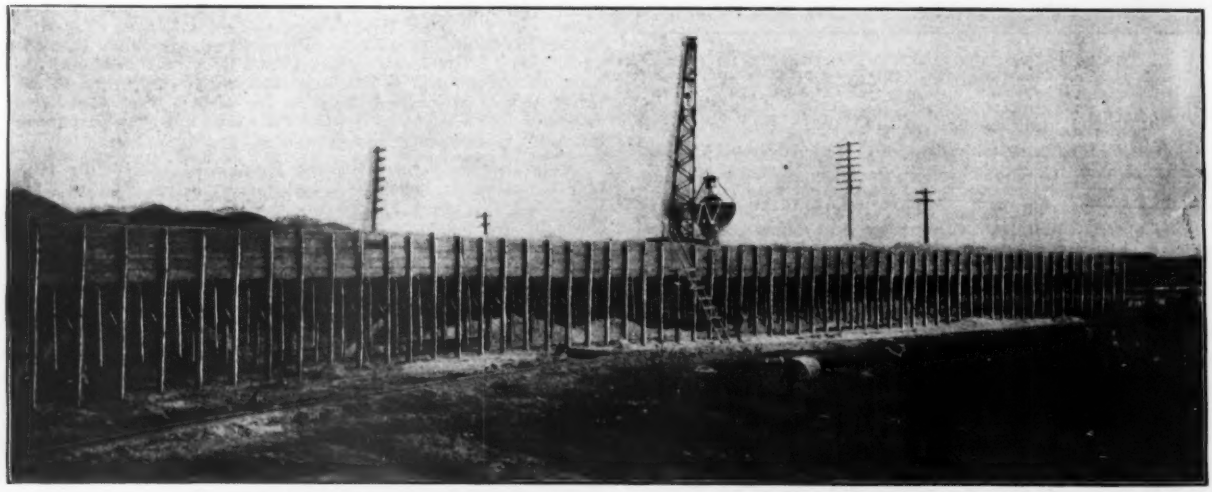


FIG. 1. UNLOADING STONE AND SAND INTO ELEVATED BINS FROM RAILROAD

*Promotion Bureau, Universal Portland Cement Co., 210 South La Salle St., Chicago, Ill.

FIG. 3. PLACING CONCRETE IN SEWER FROM MIXER TRAVELING ALONGSIDE TRENCH

Two men dump the car into the skip, by which the materials are raised into the drum. As it leaves the mixer, the concrete passes down through an adjustable chute into its place in the sewer. The chute is carried along directly by the mixer, which is self-propelling and moves along on a short piece of track (Fig. 3).

Handling concrete in this way, 400 cars a day are taken care of, which on an 8-hr. basis means 50 cars per hour, or a car practically every minute. That the mixer at this rate is working up to capacity is evident.

Dry mixing of concrete materials at a central plant, according to Mr. Kenna, the superintendent on the job, is much superior to and more economical than any other that has been tried out; and if the use of bulk cement had been considered in the original layout rather than made use of as an adaptation later on, the plan would be still more effective.

Analyzing the equipment, a means of planning similar jobs can be developed on a basis of one mule and driver and six cars to each 500 ft. of haul. At the loading end there are two men working levers and loading cars, one man pushing cars to the cement platform, one man making up the train. At the mixer there are two men on the mixer, two men dumping the cars, one man handling cars from the train.

Each job will naturally have to be considered separately in deciding as to the best layout for a central mixing plant. Among the points to be taken into consideration are nearness of railroad tracks, siding facilities, location of spur tracks, hauling distance, contractor's equipment, availability of various kinds of locomotion and character of the local surroundings.

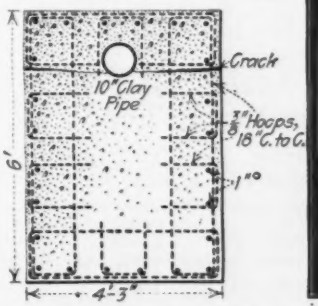
In sewer jobs similar to the one above described it has been found that a single location for a central mixing plant is economical if the plant is centrally located so that the haul at either end is no more than one mile.

The Foreign Trade of the United States in 1916 reached the enormous total of $7,873,000,000, made up of $5,481,000,000 in exports and $2,392,000,000 in imports. The exports exceeded by nearly two billion dollars the total for 1915 and by nearly three billion dollars the total for 1913. These figures surpass all previous records of foreign trade for this or any other nation.

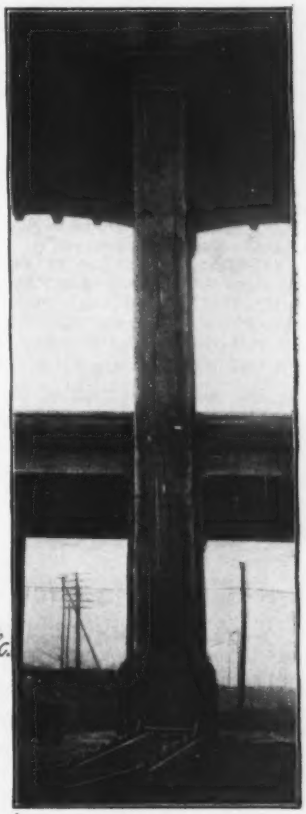
Concrete Column Cracks from Clogging of Embedded Drain Pipe

One of the tallest columns of the 12th St. double-deck reinforced-concrete viaduct in Kansas City, Mo., has been split from top to bottom of its 88 ft. of height by frost action, due to the stoppage of a drain pipe embedded in the interior. The damage was probably done following one of the late thaws last winter, but was not discovered until last fall, when the opening had become discolored and widened.

In building the viaduct four pairs of storm-water catchbasins were provided for the upper-deck 30-ft. roadway, which is 2200 ft. long and has a 5½% grade. Each of these catchbasins was connected with a 10-in. vitrified-clay sewer pipe that was embedded in the concrete of the nearest column. This pipe has two right-angled bends in the line at the top of the structure and another right-angled bend in the column footing, to allow it to pass out of the concrete to a connection with the city sewer. In the drain which caused the damage several pieces of form lumber and other débris had been allowed to drop into the pipe during the viaduct construction; these had lodged in the lower bend, stopping other fine material, until the lower 10 ft. of the vertical part of pipe was packed full. The first bend below the catchbasin was also stopped with street dirt. The freezing of the water that collected in the vertical section of the drainage line inside the column split it from top to bottom; in the upper part the cracks showed on the north and east faces, and in the lower part, where there are pilasters, on the north and south faces. The column was always in the shade.



SECTION OF COLUMN SHOWING CRACK



COLUMN CRACKED BY STOPPED DRAINPIPE

All interior drains are to be disconnected, and for a time, at least, all surface water is to be drained to the ends of the bridge. The split column will then be repaired by carefully pointing the cracks on the surface and, when this has set, filling the 10-in. clay drain pipe with a thick liquid cement grout, which by its own pressure is expected to flow into the cracks from the inside of the column and fill them out to the pointing.

News of the Engineering World

Unjust Burden on Ohio Engineers

The statutes of Ohio bearing upon the engagement of engineers on municipal improvements when the engineers do not reside in the city for which they are doing work were reviewed by W. J. Sherman, consulting engineer, Toledo, Ohio, in a paper read before the Ohio Engineering Society on Feb. 1, 1917. The paper made and commented on various citations from the statutes of Ohio. The author's summary may be quoted as follows:

(a) In the opinion of many solicitors he cannot be engaged at a fee in excess of $500 without a public advertisement and an award to the lowest and best bidder.

(b) A lawful contract cannot be entered into for his services unless it is certified that there is money in the fund not otherwise appropriated.

(c) That in many and perhaps most instances there is no money in the fund and cannot be until the bonds have been sold.

(d) That bonds cannot be sold until plans have been adopted and estimates approved.

(e) That the services of an engineer are required before the plans and estimates can be submitted.

(f) That even though money be in the fund when the service contract is executed it is likely to be transferred to the general fund at the end of the calendar year.

As a practical means of obtaining relief from these onerous conditions and of increasing the dignity of the profession Mr. Sherman suggested that the Ohio Engineering Society appoint a committee to investigate the whole subject and ask the coöperation of other engineering societies of the state to secure remedial legislative action.

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Any City May Get Advice on Almost Any Subject for Yearly Fee

For a yearly fee of $100 to $950, according to population, any city in the United States up to those having a million inhabitants may obtain "special information and advice relative to practically any phase of city government which does not involve sending staff men into the field." Such is the announcement just made by the Bureau of Municipal Research, 261 Broadway, New York City, on behalf of its newly established "B.M.R Service." The $100 fee covers any city under 30,000 population. For larger cities the fees are: 30 to 50 thousand, $190; 50 to 75, $240; 75 to 125, $350; 125 to 250, $490; 250 to 500, $750; 500 thousand to a million, $950. The announcement states that cost accounts will be kept and that if they show the fees are too high the excess will be returned pro rata, or used for general service to all subscribers, as the latter may decide—the Bureau not being a profit-making institution.

From a long list of subjects on which the Bureau stands ready to give advice the following are chosen as of most interest to engineers:

Fire: What is the best type of motor apparatus for use in a city of 25,000 population, the streets of which are comparatively level?

Parks: Should park driveways be constructed and maintained by the park department or by the public works department, and why?

Garbage Collection and Disposal: Is it more economical to use motor apparatus in making garbage collections than to use horse-drawn apparatus?

Street and Road Construction: (1) What results have been obtained in other cities from the use of concrete pavements? (2) This city is considering the purchase of an asphalt repair plant. Have such plants proved to be good economy in other cities of this size?

Street Cleaning: What is the best method of cleaning business streets which have heavy automobile traffic?

Water Department: Should water meters be owned by the city or by the consumers, and why?

Included in the Public Works and Public Utilities staff of the Bureau are seven engineers, headed by Ernest P. Goodrich, recently consulting engineer to the Borough of Manhattan, New York City. Mr. Goodrich also heads the City Planning staff and is an assistant director of the Bureau. The director of the Bureau is Frederick A. Cleveland and the assistant director is Herbert R. Sands. Bulletins regarding the B.M.R. Service and the Bureau staff may be obtained from the Bureau at the address already given.

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New York Increases Motor-Truck Fees

The schedule of fees for motor trucks adopted by the commission appointed by the legislature of New York last fall, has been made law, and went into effect Feb. 1. It is estimated that the new schedule will provide an increased revenue from motor-vehicle fees of $600,000, which will be equally divided beetween the state and the municipalities and be devoted to highway maintenance. The two public hearings of the commission were reported in *Engineering News*, Nov. 23, and Dec. 28, 1916.

The following is the new schedule of annual fees: For motor vehicles used as omnibuses for the transportation of passengers, $15 for five-passenger capacity or less, $24.50 for 6 to 7 passenger cars, $30.50 for 8 to 10, $43 for 11 to 16, $52 for 17 to 20, $55 for 21 to 22, $61.50 for 23 to 26, $67.50 for 27 to 30 passenger cars and $2 for each passenger capacity of all cars of over 30-passenger. For motor trucks used for the transportation of goods, wares and merchandise the fees are: $10 for less than 2 tons combined weight and capacity and $5 for each extra ton of combined weight and capacity up to 14 tons, making $70 for a truck of this size. Above 14 tons the annual fee increases in $10 increments for each ton.

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To Reclaim 300,000 Acres of Land in Northeastern Arkansas

Plans have been drawn by the Morgan Engineering Co., Memphis, Tenn., for a drainage project to cost $3,000,000, the object being to reclaim 300,000 acres of land in Mississippi, Craighead and Poinsett Counties, Arkansas. This project provides for the construction of 300 mi. of ditch and 54 mi. of levees, requiring the moving of 30,000,000 cu.yd. of earth. This is claimed to be the second largest drainage district in the United States.

The control of floods along the Little River constitutes the most important and expensive part of the reclamation work. One section of the flood channel is to consist of a ditch 5 mi. long, 280 ft. wide at the base and 18 ft. deep. One unusual feature of the project is the draining of 20,000 acres through a three-barrel reinforced-concrete culvert under the main floodway. This land is lower than can be drained by the principal ditches and the culvert system is designed to save the cost of pumping.

The project will be split up into a number of contract sections and it is estimated that construction will require three years' time. The work of computing the assessments is now under way.

Famous Passaic Gas Case Abandoned

It has been announced that there will be no argument in the United States Supreme Court in the so-called Passaic Ninety-Cent Gas case, as an agreement by stipulation has been reached for dismissing the appeal of the Public Service Gas Co. from the decision of the New Jersey Court of Errors and Appeals. As noted at various times in *Engineering News* (Jan. 23, 1913, Dec. 24, 1914, Jan. 21, June 17 and July 1, 1915) the State Board of Public Utility Commissioners made a valuation of the company's property, in an action to reduce rates, and refused to allow an item of about a million dollars for franchise value. The company's appeals were fruitless in the state courts.

NOTES

Outfall Sewer Construction at Los Angeles, Calif., is being carried on with such funds as the city can secure pending a bond issue for all the works, including proposed Imhoff tanks, required to carry out the orders of the State Board of Health to lessen the pollution of the Pacific Ocean.

The New Colorado River Intake Gate for the main canal of the Imperial Irrigation District, will be built by M. D. Goodbody, of San Diego, Calif., late reports state, instead of by the Ross Construction, of Sacramento, Calif., as announced in "Engineering News" of Feb. 1, 1917. The contract price is given as $232,000. C. K. Clarke, Calexico, Calif., is chief engineer of the Imperial Irrigation District.

Damages for the Lower Otay Dam Failure in the sum of $122,500 have been asked in a suit brought against the City of San Diego, Calif., by the Western Salt Co. The company urges that its works on San Diego Bay were destroyed and a large quantity of salt and brine lost by the flood waters that followed the breaking of the dam. The plaintiff alleges that the dam was of poor design and that the city had long known that the structure was leaky and insecure.

Vehicle Tunnels under the Hudson River at New York City are being agitated by public authorities in New Jersey. The county authorities of Bergen and Hudson Counties are each ready to contribute $10,000 toward preliminary surveys to determine the feasibility and financial possibility of constructing such tunnels and it is reported that Essex County may shortly make a similar contribution. The work can then go forward in accordance with a state enabling act.

Bad Taste and Odor in the Cleveland Water-Supply the latter part of January led Mayor H. L. Davis to order Utilities Director T. S. Farrell to cut the amount of chlorine used for disinfecting the water from 10 to 7 lb. per 1,000,000 gal., although the health and water departments appear to think the larger amount is needed for safety. The City Council unanimously authorized its Committee on Health and Sanitation to investigate the chlorine situation. Council also called on the Director of Law to report where the responsibility for the character of the water-supply from a health viewpoint rests.

Land Reform in the State of Yucatan, Mexico, is being carried out by a commission, of which a civil engineer, Modesto C. Rolland, is the chairman. The object of the commission is to distribute the land among the native Indians and to carry out a revaluation of land properties for tax-assessment purposes. According to a published statement by Mr. Rolland, the land in Yucatan was formerly practically free of taxation. The total land taxes collected in the state amounted to only $50,000. The total valuation of lands was about $32,000,000. The commission has conducted a reappraisal, raising the valuation to $231,000,000, and from these lands the state is now receiving about $3,000,000 per annum in revenue.

New Park Lands by Dumping Refuse are proposed by the Chicago Plan Commission, which estimates that in 12 years 1300 acres of new land can be made in this way along the lake front of the south side of the city. The aggregate value of this land would be about $46,000,000. Nearly 40,000,000 cu.yd. of material would be required and the city would receive in cash about $3,000,000 for dumping privileges. The only initial expense would be for the construction of retaining walls. The present city dumps are nearly full and some new locations must be found away from the densely populated sections where the present dumps exist. The material for such dumping includes building wastes, excavated material, ashes, household rubbish and street sweepings. Filling of this kind has been used already for improvements along the lake shore in the north-side district of Chicago, and a water front park at Buffalo, N. Y., has been made in the same way.

New Westinghouse Center—Announcement has just been made by the Westinghouse Electric & Manufacturing Co. that the 500-acre plot of ground recently purchased at Essington, near Philadelphia, will form a new industrial center devoted to the production of large apparatus, the first group of buildings being for power machinery, principally steam turbines, condensers, and reduction gears. The initial development will cost in the neighborhood of $5,000,000 or $6,000,000 and will occupy about one-fifth of the area of the entire plot. The group will consist of two large machine shops, an erecting shop for heavy machinery, forge shop, pattern and pattern-storage shop, and power house. Work will begin on these as soon as satisfactory building contracts can be let. The site has a frontage of approximately 1 mi. on the Delaware River. Additional transportation facilities will be afforded by tracks from the Pennsylvania and the Philadelphia & Reading railroads. The number of employees is expected eventually to equal that at the East Pittsburgh center.

Enlargement of Railway Facilities at Baltimore, Md., at a cost of about $15,000,000, is provided for in plans submitted by officers of the Pennsylvania R.R. to Mayor Preston, of Baltimore, on Jan. 24. At present the four-track main line of the Pennsylvania R.R. from Philadelphia to Washington is reduced to two tracks through the City of Baltimore. The railway desires to secure two additional tracks through the city and proposes to parallel the present tunnel under Hoffman St. and the present Baltimore & Potomac tunnel under Wilson St. by two single-track tunnels. The yards at the Union Station are to be enlarged, and additional trackage and new freight sheds are to be built at the Calvert St. freight terminal. The reason for building the additional lines through the city as single-track tunnels instead of double-track is probably to secure better ventilation, since the movement of trains through a single-track tunnel of short length usually provides all necessary ventilation without artificial means. The work will require the closing of several streets, and ordinances providing for this and other necessary features in connection with the work have been introduced into the City Council. The city authorities are inclined to insist on electrification of the lines through the city before granting the permits for the work in question, but the Pennsylvania officials have heretofore gone on record as opposed to the adoption of electrification, since it would involve a very large and unnecessary expense and interfere seriously with the movement of through trains.

PERSONALS

J. W. Shiffman has been appointed City Electrician of Cleveland, Ohio.

E. C. Woodward, Assoc. M. Am. Soc. C. E., Engineer of Pavements, Dallas, Tex., has resigned.

John R. Slade, recently with the Wateree Power Co., Longtown, S. C., is now with the Braden Copper Co., at Rancagua, Chile.

Ralph N. Priest, formerly President of the W. E. Wark Co., has opened offices at 1737 Filbert St., Philadelphia, Penn., as Consulting Engineer.

C. B. Clegg has been appointed Acting Division Engineer of the Atchison, Topeka & Santa Fe Ry. at Clovis, N. M., succeeding J. W. Walter.

Dr. S. S. Goldwater, former Health Commissioner of New York City, has been appointed Consultant on Health and Hospitals, without salary.

Duncan Buie, of Richland Parish, has been appointed State Highway Engineer of Louisiana, succeeding W. E. Atkinson. The salary is $4000 per annum.

J. A. Nelson, M. Am. Soc. C. E., has resigned as Vice-President of the East Jersey Pipe Corporation, New York City, and for the present will take a vacation and rest.

E. P. Roberts, M. Am. Soc. M. E., Consulting Engineer, formerly Smoke Commissioner of Cleveland, Ohio, has been appointed Efficiency Engineer of the Philadelphia Rubber Works Co., Akron, Ohio.

J. A. Amyot, former Director of the Ontario Board of Health laboratories, Toronto, Ont., is now Sanitary Advisor, with the rank of Major, of the Canadian forces of the British Army in England.

C. E. Lehman has been appointed Engineer in Charge of the Third Engineering District of St. Louis County, Minnesota, at a salary of $2000 per annum, under R. W. Acton, County Engineer, Duluth, Minn.

Columbus K. Lassiter has been elected Vice-President in charge of manufacture of the American Locomotive Co., Schenectady, N. Y. **Harry B. Hunt** is Assistant Vice-President in charge of manufacture.

R. J. Rich has been appointed Engineer in Charge of the Second Engineering District of St. Louis County, Minnesota, at a salary of $2000 per annum, under R. W. Acton, County Engineer, Duluth, Minn.

H. H. Magdsick, an electrical engineer of the National Lamp Works, Cleveland, Ohio, has been given a gold medal for his work in supervising the lighting of the Statue of Liberty, New York Harbor.

H. J. Moore, recently Division Engineer of the Atchison, Topeka & Santa Fe Ry., Arkansas City, Kan., has been promoted to be General Inspector of Transportation, Eastern Lines, with office at Newton, Kan.

T. T. Harrison has been appointed Engineer in Charge of the First Engineering District, St. Louis County, Minneapolis, under R. W. Acton, County Engineer, Duluth, Minn. The salary of this position is $2000 per annum.

C. M. Upham, Assoc. M. Am. Soc. C. E., recently Chief Engineer of the Bureau of Inspection of the Coleman du Pont Road, Inc., has been appointed County Engineer of Sussex County, with headquarters at Georgetown, Del.

Henry Cummings, formerly Resident Manager of Wells Brothers Co., Building Contractors, Boston, Mass., has opened offices in the Unity Bldg., Boston, for private practice. The Wells Brothers Co. has retired from the Boston territory.

Robert H. Young, of Louisville, Ky., has been appointed Engineer in charge of McCracken County road work, with headquarters at Paducah, Ky. Bonds have been issued to the amount of $200,000 for improving the roads of this county.

Frederick J. Herring, of Little Rock, Ark., and **Harrison Schellhouse,** of Chicago, Ill., have formed a partnership under the name of Herring & Schellhouse, Civil Engineers, Forest City, Ark. Both are graduates in civil engineering of Purdue University.

Louis Yager, Division Engineer of the Northern Pacific Ry. at St. Paul, Minn., has been promoted to be Acting Engineer of Maintenance-of-Way of the lines east of Paradise, Mont., with office at St. Paul. **Bernard Blum** succeeds him as Acting Division Engineer at St. Paul.

R. K. Stockwell, Assoc. M. Am. Soc. C. E., recently Chief Engineer and Superintendent of Construction of the Braden Copper Co., at Rancagua, Chile, will soon open offices in Salt Lake City, Utah, as the engineering and sales representative of the Robins Conveying Belt Co., of New York.

F. W. Claflin, Assoc. M. Am. Soc. C. E., Assistant Engineer of Grade Crossing Elimination, New York, Chicago & St. Louis R.R., Cleveland, Ohio, has resigned to accept the position of Superintendent of Construction for S. M. Marshall, Consulting Engineer, New York City, on work in Toronto, Ont.

W. H. Kuts has been appointed City Engineer of Parsons, Kan. He was graduated from Kansas University in 1904 and has been with the engineering departments of the Missouri, Kansas & Texas Ry., the Atchison, Topeka & Santa Fe Ry., the United States Land Office and the Denver Union Water Co.

G. W. Ellis, Assoc. M. Am. Soc. C. E., has been appointed City Engineer of Pratt, Kan. He is a graduate of Kansas University, class of 1908, and was for six years employed by Burns & McDonnell, Consulting Engineers, Kansas City, Mo. Later he was City Engineer and Superintendent of Water-Works at Osage City, Kan.

James W. Long will terminate his services as Bacteriologist of the Trenton, N. J., water-purification plant Feb. 28, the office having been abolished. The reason given in the published report of the city commission is that of economy; the work in the future will be done by the superintendent of the plant with a laboratory assistant, under the supervision of the City Chemist.

L. K. Rourke, M. Am. Soc. C. E., former Commissioner of Public Works, Boston, Mass., has accepted a position in an advisory capacity with the Chile Exploration Co. and the Braden Copper Co., of New York City. He has recently returned from a trip to Chile and will leave again for that country within a month. He states that mining industries are active and that many public-works improvements are contemplated in Chile, but that the latter are, and probably will be, handled chiefly by Chilean engineers.

E. B. Merriam, for several years Assistant Engineer of the Switchboard Department of the General Electric Co., has resigned his position to assume much more important duties. He now heads the Industrial Service Department recently organized to supervise education, employment, and provision of opportunities for advancement of employees at the Schenectady plant of the company. He has been connected with the General Electric Co. for 16 years, starting as a student in the testing department and later doing service in commercial, manufacturing and engineering development and research departments.

S. T. Henry, Assoc. Am. Soc. C. E., has resigned as Second Vice-President of the McGraw Publishing Co., New York City, to become Vice-President of a subsidiary of the American International Corporation, which will handle the export of contractors' machinery and equipment. He is a graduate of the University of Illinois, class of 1904, and joined the editorial staff of "Engineering Record" the same year. For a time he was Western Editor at Chicago and afterward Advertising Representative. Recently he has been active in the business management of all the McGraw Publishing Co.'s technical papers.

Charles A. Norman, formerly instructor in charge of farm-structure work, Purdue University; **L. H. De Muta,** formerly manager of the Cement Stave Silo Co., Sedalia, Mo., and a graduate in agriculture of the University of Missouri; and **W. G. Kaiser,** formerly experimentalist in farm building design, Iowa State College, have recently taken positions with the Portland Cement Association at the Chicago headquarters. These men will devote their efforts to extending the activities of the Extension Division Farm Bureau of the Portland Cement Association. Mr. Kaiser will have charge of farm building design, Mr. De Muth will devote his attention to rural-contractor coöperation and general farm-promotion work, while Mr. Norman will be engaged in investigational inquiry work.

Walter Kidde, Engineer-Constructor, New York City, has incorporated his organization under the title of Walter Kidde & Co., Inc. Mr. Kidde's chief associates, who have been his partners on the "Carnegie plan," now become directors and stockholders of the new corporation, the officers of which are: Walter Kidde, President; B. G. Worth, Vice-President; I. R. Lewis, Secretary and Treasurer. These are all members of the Board of Directors, which also includes Henry Lang, who is Vice-President of the Ingersoll-Rand Co., and E. S. Boyer, who is associated with the American Hard Rubber Co. The other principal associates, who comprise the "engineering board" of the corporation, are: A. B. Miller, Walter S. Wainright, M. I. Buttfield, and E. Schwarz. The chief draftsman is Thorlief Fliflet.

OBITUARY

Oliver Howell Crittenden, Chief Engineer of the International & Great Northern Ry., died Jan. 27 at his home in Houston, Tex.

James K. Lake, a retired engineer and contractor of Chicago, Ill., died Jan. 23 at his home in Council Grove, Kan. He was born in Connecticut and went to Chicago in 1858.

Charles J. Moore, a prominent mining engineer of Denver, Colo., died at his residence in that city on Jan. 28, after a month's illness. Mr. Moore was born in England, but had resided in the United States during nearly all his active business life. In the early '70's, Mr. Moore made the acquaintance of George H. Frost, the founder of "Engineering News."

When Mr. Frost began the publication of this journal at Chicago in April, 1874, Mr. Moore assisted him in editing it until the close of the year, when he returned to New York City. Mr. Frost's original idea in founding the journal was to publish a paper exclusively for land surveyors. It was through Mr. Moore's influence that he chose a wider field and adopted as the title for the journal, when first issued, "The Engineer, Architect and Surveyor." During his residence of over 40 years in Colorado, Mr. Moore was connected with some of the principal mining developments in that state at Leadville and Cripple Creek, and later at Goldfield, Nev. He was connected with the Portland mine at Cripple Creek for a number of years and located and developed some of the best mines in Goldfield. Mr. Moore is survived by his widow and one son.

Lyman E. Cooley, Consulting Engineer, of Chicago, died on Feb. 3 after a brief illness. He addressed a meeting of the Western Society of Engineers on Jan. 31. Mr. Cooley was born at Canandaigua, N. Y., Dec. 5, 1850, and graduated at Rensselaer Polytechnic Institute in the class of 1874. He was for three years a teacher in Northwestern University and for six years, from 1878 to 1884, was in the United States Engineer Service, engaged in the improvement of the Mississippi and Missouri Rivers. He first became prominent for his energy in promoting the undertaking of the Chicago Drainage Canal. He served as its Chief Engineer for some time, and when through some political combinations he was displaced, he was elected one of the Trustees of the district. In 1895 he was appointed by President Cleveland a member of the Commission to make investigations for a ship canal between the Great Lakes and the Atlantic; and he was prominent in connection with all the later plans for deep-water navigation to the Lakes. He was Consulting Engineer of the Lakes-to-the-Gulf Deep Waterway Association for several years. Besides his work in connection with waterway development, he did notable work in connection with water-power enterprises and water storage at Keokuk, Iowa, and at Denver. Mr. Cooley was a prolific writer on the engineering subjects in which he was interested. He was Editor-in-Chief of "Engineering News" for a year, in 1876-77, and was for many years afterward a frequent contributor to its columns. In 1884 he with some associates founded "The American Engineer" in Chicago, but his connection with it was brief. He delivered lectures on waterway topics at Illinois, Michigan and Wisconsin universities and was given the degree of Doctor of Engineering by Michigan University, in 1915. He became a member of the American Society of Civil Engineers in 1898, and was President of the Western Society of Engineers in 1890-91. He leaves a son, a daughter and seven brothers, one of whom, Dr. M. E. Cooley, is Dean of the Engineering College of Michigan University.

ENGINEERING SOCIETIES

TENTH CHICAGO CEMENT SHOW.
Feb. 7-15. In Chicago. Under management of Cement Products Exhibition Co., 210 South La Salle St., Chicago.

AMERICAN CONCRETE INSTITUTE.
Feb. 8-10. In Chicago at La Salle. Secy., H. D. Hynds, 30 Broad St., N. Y.

AMERICAN ASSOCIATION OF ENGINEERS.
Feb. 8-10. In Chicago at the Hotel La Salle.

NATIONAL BUILDERS' SUPPLY ASSOCIATION.
Feb. 12-13. In Chicago at Sherman. Secy., L. F. Desmond, 1211 Chamber of Commerce, Chicago.

ARKANSAS ENGINEERING SOCIETY.
Feb. 13-14. Annual meeting in Little Rock. Secy., Wm. J. Parkes, Pine Bluff, Ark.

INDIANA SANITARY AND WATER-SUPPLY ASSOCIATION.
Feb. 14-15. Annual meeting in Indianapolis. Secy., W. F. King, Indianapolis, Ind.

WISCONSIN ENGINEERING SOCIETY.
Feb. 15-16. At Madison, Wis. Secy., L. S. Smith, 939 University Ave., Madison, Wis.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Feb. 19-22. Meeting in New York City. Secy., Bradley, Stoughton, 29 W. 39th St., New York City.

SOUTHWESTERN CONCRETE ASSOCIATION.
Feb. 19-24. Southwestern Concrete Show in Kansas City, Mo. Address Chas. A. Stevenson, 1413 W. 10th St., Kansas City.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.
Feb 20-21. Annual meeting in New Haven in Mason Laboratory. Secy., J. F. Jackson, New Haven.

IOWA STATE DRAINAGE ASSOCIATION.
Feb. 20-21. Meeting in Fort Dodge. Secy. M. F. P. Costelloe, Ames.

IOWA ENGINEERING SOCIETY.
Feb. 21-23. Annual meeting in Ames. Secy., J. H. Dunlap, Iowa City.

The Idaho Society of Engineers at its recent convention elected the following officers: President, Will H. Gibson; vice-presidents, W. O. Cotton and G. C. Scharf; secretary, Ira F. Shaffner, of Boise, Idaho.

The Engineers' and Architects' Association of Southern California elected on Jan. 27 the following officers for 1917: President, A. H. Koebig; vice-presidents, A. S. Bent and I. J. Francis; secretary, H. Z. Osborne, Jr., City Engineer of Los Angeles.

The Engineers' Club of Minneapolis has elected the following officers for 1917: President, E. H. Scoffield; vice-president, Walter F. Milnor; treasurer, P. R. Thompson; secretary, E. W. Ashenden.

The Engineering Society of York, Penn., at the recent annual meeting elected the following officers: President, George A. Jessop; vice-president, Chauncey D. Bond; treasurer, Harold A. Russel; secretary, M. H. Frey, Polack Building, York, Penn.

The American Institute of Mining Engineers convenes in New York City on Feb. 19 for the annual meeting. In addition to the regular business and the presentation of technical papers there will be an all-day excursion by special train to West Point.

The Indiana Sanitary and Water-Supply Association holds its tenth annual meeting Feb. 14 and 15 at Indianapolis at the Claypool Hotel. In addition to the various papers and committee reports, there will be four roundtable discussions on the following subjects: "Surreptitious Use of Water," "Meter Department Operation," "Water-Works Accounting," and "Extension of Distribution System." A leaflet has been distributed containing questions intended to serve as a guide in the discussions.

The Building Officials' Conference will be held in Washington, D. C., May 10 and 11, which time will coincide with that of the annual meeting of the National Fire Protection Association. A joint meeting of the two societies will be held on May 10. There will be an address on safe and unsafe scaffolds and the prevention of accidents to building workmen, and a paper describing the organization and purpose of building departments throughout the country. The secretary is Sydney J. Williams, Madison, Wis.

The Connecticut Society of Civil Engineers holds its thirty-third annual meeting in New Haven Feb. 20 and 21. Among the papers to be presented are "Deep Foundations," by James W. Rollins, of Holbrook, Cabot & Rollins Corporation; "The Development of Car-Float Transfer Bridges in New York Harbor," by J. B. French, and "Notes on Construction and Maintenance of Electric-Railway Track," by P. N Wilson. The annual dinner will be held at the Hotel Taft, at 6:45 on the first day. The secretary is J. Frederick Jackson, New Haven, Conn.

The Ohio Engineering Society held its annual meeting in Columbus, Jan. 29 to Feb. 2, electing the following officers: President, A. R. Taylor; vice-president, T. J. Smull; secretary, John Laylin, Norwalk. The principal subject under discussion was a proposed Columbus Engineering Society. About fifty of the members present indicated a willingness to join such an organization, and a motion was passed unanimously providing for a committee to be appointed by the president, which would meet with a like committee of the Ohio Society of Mechanical, Electrical and Steam Engineers, looking to a consolidation of the two. The next annual meeting of the Ohio Engineering Society will be held at Columbus, and at that time it is likely that there will be a general convocation of Ohio engineers.

The Society of Terminal Engineers has just been chartered under the laws of New York, with headquarters in New York City. Its purposes are to promote the study of terminal engineering and of mechanical freight handling. There are members, associate members and juniors. The members' grade is open to engineers specializing in terminal work and to professors of civil and mechanical engineering. Associate membership applies to officers and others connected with concerns manufacturing freight-handling appliances and terminal equipment. Junior members comprise recent technical graduates. The dues are $6 a year, without initiation fee for the first year. It is expected that monthly meetings will be held. The officers are: President, H. McL. Harding; vice-presidents, Gen. W. H. Bixby and John Meigs; treasurer, W. J. Barney; secretary, J. Leonard, 1133 Broadway, New York City.

The Engineers Club of New York City, although a purely social organization and not a technical society, is of especial interest to engineers because its membership is made up very largely of prominent members of the principal national engineering societies. The club's house in New York City is located in 40th St., closely adjacent to the Engineering Societies' Building on 39th St. The money to erect the club build-

ing was given by Andrew Carnegie at the same time that he made his great gift for the building of the national engineering societies. The annual report of the Board of Managers of the club, just issued, shows a total membership of 2146, of whom 1200 reside in or near New York City. The distribution of members in the profession is indicated broadly by the list of 94 members elected during 1916. Of these, 39 were mechanical engineers, 20 electrical engineers, 10 civil engineers, 7 mining engineers, 7 marine engineers, and the remaining 11 were manufacturers, contractors, efficiency engineers, etc. The club had a gross income last year of about $485,000, and its expenses were about equal in amount. The total assets are about $1,150,000, and practically its only liabilities are a mortgage for $300,000 on its real estate. E. G. Spilsbury is the President of the club for 1917, and Joseph Struthers is Secretary.

Appliances and Materials

A Suit Life Preserver

A buoyant suit designed primarily for use as a life preserver is announced by the National Life Preserver Co., 11 Broadway, New York City. The suit, known as the "Ever-Warm," was invented by O. A Youngren and is made in "union" style—in one piece with shoes and mittens—completely inclosing the body, with the exception of the head, which is protected by a waterproof cap. Lead soles keep the wearer right side up. The suit is of waterproof material and does not depend for buoyancy upon air that may be confined within it. The upper portion is lined with "Ilanasilk," a waterproof material claimed to be five times as light as cork. The suit is not easily punctured, but it may be filled with water without diminishing its buoyancy. Across the upper front, between the shoulders, is a wide opening; this is closed, after putting the suit on by hinged half-hoops snapped together. The head comes through a hole in the flap top.

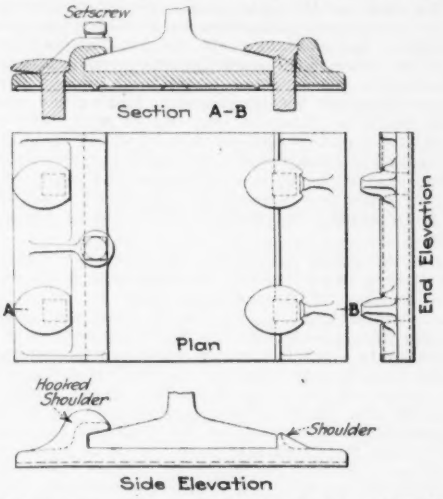
* * *

Rail-Anchor Tie-Plate

The Thomas rail-anchor tie-plate, shown herewith, combines the functions of a tie-plate and an anticreeping device. It has been applied with success, not only on the open track, but at points on terminal lines where conditions of track crossings, sharp curves and heavy traffic unite to make it difficult to hold track in line and gage. It is manufactured by the Chicago Malleable Castings Co., of Chicago, Ill.

The device is a malleable-iron tie-plate with a hooked shoulder to grip one side of the rail base, and a plain shoulder to fit against the other side. The width between shoulders is made an exact fit for the rail base. On the side of the hooked lug, the plate is secured by one or two spikes that do not engage the rail. On the other side are similar spikes that hold both the rail and the plate. A special feature is a lug or shoulder at the back of each of these latter spike holes, so shaped as to hold the spike tightly against the rail and to prevent the spike from being driven in an inclined position. In this way the rail is held firmly between the spikes and the shoulder.

To prevent any longitudinal motion or creeping, a setscrew in the hooked lug is screwed down so as to bite into the rail base. No great force is required for this; and where the device has been in use for a considerable time, it has been found that the setscrew neither rusts tight nor works loose. The bottom of the plate has shallow ribs, as shown. The device may be used on all or a portion of the ties, according to the extent of the trouble with creeping. Some roads prefer it on all ties, even where this trouble is less serious, rather than have two different kinds of tie-plate in use in the same stretch of track.



COMBINED TIE-PLATE AND RAIL ANCHOR

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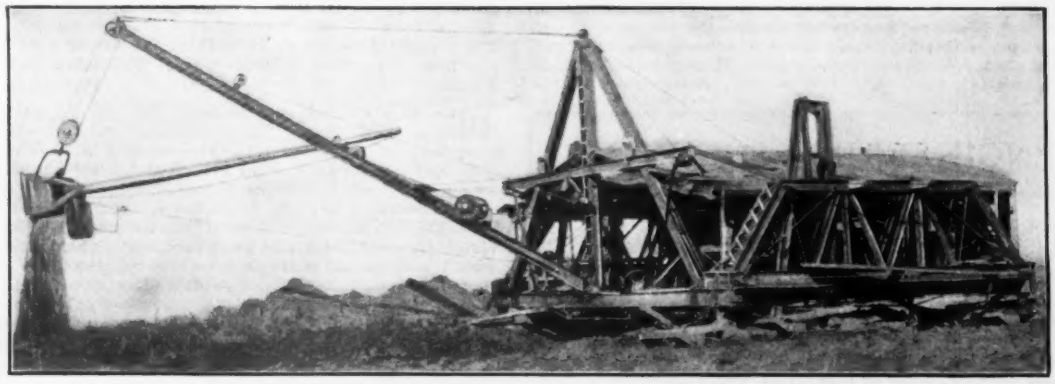
New Walking Land Dredge

A new kind of walking land dipper dredge using a series of feet in place of steel trucks and sectional track is announced by the Bay City Dredge Works, Bay City, Mich. Four corner feet are attached permanently to the four corners of the dredge, and two large movable feet are located in the center, one on each side. The dredge body, together with the corner feet, is lifted and pulled forward by winding up a move-up cable on a hoist drum. Then the center foot-frames are pulled forward and another cycle repeated. From 5 to 10 ft. is covered per shift and two steps can be made per minute. The dredge can move across open country at the rate of 1 to 2 mi. in 10 hr. Ground that is rough, marshy, soft or slippery does not impede the walking dredge, and no track, skids or extra planking is required. The manufacturer has had one of these dredges in service during the digging season of 1916 in northwestern Minnesota.



WALKING DREDGE WITH TWO MOVABLE AND FOUR STATIONARY FEET

* * *

Another Thin-Plate Air Valve

The Mesta Machine Co., of Pittsburgh, is now using on its blowing engines and compressors a thin-plate valve made under the Iverson patents. It was intended to be adopted only for new equipment, but it was found possible to install it easily and cheaply on old machines. The valve consists of a light, thin, annular steel plate carried and guided by a flat volute spring. The valve plate is not deformed in operation, but keeps parallel to the seat. In common with most modern plate valves, the valve movement is small, full opening is quickly secured, very little back pressure is caused, and there is no appreciable wear. Increases are reported of from 10 to 35% in air delivery without increased piston speed. An increase in efficiency of 1 to 5% is also claimed.